CARPENTRY

AMERICAN SCHOOL of CORRESPONDENCE
CHICAGO ILLINOIS
U. S. A.

PART I

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CARPENTRY

PART I

INSTRUCTION PAPER

PREPARED BY

GILBERT TOWNSEND, S.B.

WITH POST AND MCCORD, NEW YORK CITY
FORMERLY INSTRUCTOR IN ARCHITECTURE
AMERICAN SCHOOL OF CORRESPONDENCE

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PART I.

The art of Carpentry has been practiced by men in all ages and in all lands, and is likely to continue as long as there is any timber out of which dwellings and utensils can be made. Under different conditions and in widely separated parts of the world there have been developed various methods of doing the same work, and men have attained to various degrees of proficiency in the handling of tools, and in the making of the tools themselves. From the time when the primitive man built himself a hut out of brush-wood and mud, to the present day, when we live in comfortable dwellings built of seasoned timber, there has been constant progress and development, so that there has accumulated a vast amount of experience to which we are the fortunate heirs.

The carpenter has always found his material at hand, provided by nature, and needing only to be cut down and shaped to suit his purposes. In those places where wood did not grow near by, there were no carpenters; but instead, workers in stone or clay.

A knowledge of the characteristics of wood, which plays so important a part in all our lives and which is so plentiful in our own land, is likely to prove of advantage to anyone, and is an absolute necessity to a carpenter. Let us therefore, first of all, devote some space to a consideration of timber, both in its natural state, and in its commercial form as prepared for the market.

NATURAL TIMBER.

Wood is one of the most common of building materials, and may be seen everywhere in its natural state as well as in various forms prepared for use. It is all taken originally from some kind of tree or shrub, and a consideration of the manner of growth of the tree itself will explain many peculiarities and defects of timber in its commercial form.

Classes of Trees. The trees from which most of our timber is taken are of two kinds: the "broad-leaved," such as the oak, poplar, and maple, and the "conifer" or "needle-leaved," such as the pines, the fir, and the cedar. In the South some timber is used which comes from another class of trees, of which the palms are the most common representatives; the use of this timber, however, is very limited. In general, it may be said that the wood from the broad-leaved trees is "hardwood" while that from the conifers is "softwood," but this rule does not hold true in all cases.

Manner of Growth. There is a marked difference between the three classes of trees mentioned above in regard to their manner of growth. While the members of the third class, the palms and others, grow only at the top, and have the same diameter of trunk after years of development, the members of the other two classes increase in size of trunk as well as in height. Each year a new layer of wood is formed on the outside of the trunk and branches, underneath the bark, and the age of the tree may usually be determined by counting the number of layers. In the center of the tree there is always a small whitish part, called the "pith," about which the wood itself is arranged in concentric rings, as shown in Fig. 1, in which A is the pith, B the woody part of the tree, and C the bark. The arrangement of the wood in concentric rings is due to the fact that it was formed gradually, one layer being added each year, and for this reason the rings or layers are called "annual rings."

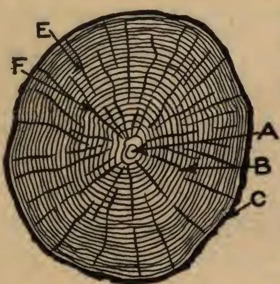


Fig. 1. Section of Log.

The wood nearest the center, or pith, is considerably harder and darker in color than that which is on the outside nearer the bark; it is called the "heartwood" to distinguish it from the other which is called the "sapwood." Only the heartwood should be used for building work. The reason why it is harder than the sapwood is that it is older and has been compressed more and more each year as the tree has increased in size, and the pores have gradually become filled up. The sapwood is soft and of lighter color and shows that it has been recently formed. The time required to transform the wood from sapwood into heartwood varies from nine to thirty-five

years, according to the nature of the tree, and those trees which perform this hardening in the shortest time are usually the most durable. The sap rises in the spring from the roots of the tree to the branches and twigs, forming the leaves, and in the autumn it flows back again between the wood and the bark. Thus a new annual ring is formed.

The width of the annual rings varies from $\frac{1}{50}$ inch to $\frac{1}{8}$ inch according to the character of the tree and the position of the ring. In general it may be said that the widest rings are found nearest the center, or pith, and that they grow regularly narrower as they approach the bark. Also they are wider at the bottom of the trunk than at the top. The rings are very seldom circular or regular in form, but follow the contour of the tree trunk.

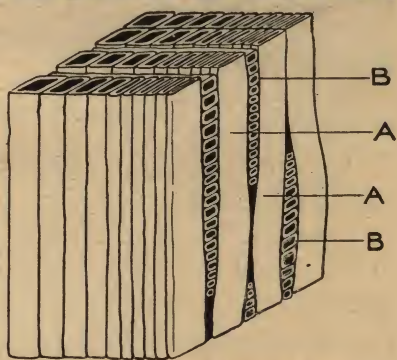


Fig. 2. Arrangement of Fibers.

In addition to the annual rings there may be seen on the cross-section of any log other lines which run from the center toward the bark at right angles to the annual rings. These are called the "medullary" rays. Usually they do not extend to the bark, but alternate with others which start at the bark and run inward toward the center but are lost before they reach the pith. This is shown at E and F in Fig. 1.

Details of Structure. The two above-mentioned classes of wood differ considerably in their structure, that of the conifers being very simple and regular in arrangement, while that of the broad-leaved trees is complex and irregular. The wood is made up of bundles of fibers or long tubes, parallel to the stem of the tree, which are crossed by other fibers that form the medullary rays, passing from the pith to the bark and binding the whole together. Besides these there are resin ducts and other fibers scattered through the trunk of the tree. The arrangement is shown in Fig. 2. A A are the long fibers, and B B the pith or medullary fibers. Of course these are so small that the individual fibers cannot be distinguished without the aid of a powerful microscope. In pine more than fifteen thousand pith rays occur on a square inch of section.

Grain of Wood. Woods are commonly spoken of as "fine-grained," "coarse-grained," "cross-grained," or "straight-grained." The wood is said to be fine-grained when the annual rings are relatively narrow, and coarse-grained when these rings are wide. Fine-grained wood can be made to take a high polish while with coarse-grained wood, in general, this is not possible. When the fibers are straight, and parallel to the direction of the trunk of the tree, the wood is said to be straight-grained, but if they are distorted or if they are twisted so as to be spiral in form, not growing straight up but following around the trunk of the tree, the wood is said to be cross-grained.

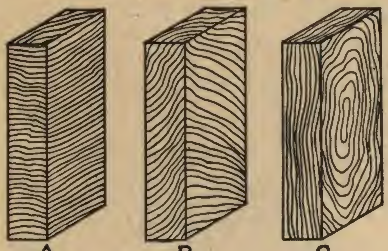


Fig. 3. Grain of Wood.

In Fig. 3 are shown three pieces of timber of which A is absolutely cross-grained, B is partially cross-grained and C is straight-grained.

Defects. Most of the defects which render timber unsuitable for building are due to irregularities in the growth of the tree from which the timber was taken. These defects are known by various names, such as "Heartshakes," "Windshakes," "Starshakes," and "Knots." Other defects are due to deterioration of the timber after it has been in place for some time or even before the tree has been felled, among which are "Dry Rot" and "Wet Rot." The defects of the first class are defects of structure — those of the second class are defects of the material itself.

Fig. 4. Heartshake.

Heartshake. Fig. 4 shows what is known as a heartshake. There is first a small cavity at the heart of the tree caused by decay, and flaws or cracks extend from it out toward the bark. The heartshake is most often found in those trees which are old, rather than in young, vigorous saplings; it is especially to be feared in hemlock timber.

Windshake. Fig. 5 shows what is known as a windshake or cupshake. This is caused by a separation of the annual rings one from another so that a crack is formed in the body of the tree; this

crack may extend for a considerable distance up the trunk. This defect is said to be caused by the expansion of the sapwood, and it is also claimed that it is caused by the wrenching to which the tree is subjected by high winds. Windshakes are very often found in pine timber.

A *starshake* is very much like a heartshake, the chief difference being that the starshake cracks extend right across the center of the trunk without any appearance of decay at that point.

Fig. 5. Windshake.

Dry rot in timber is caused by a fungus growth, and takes place most readily when the timber is in such a position that it is alternately wet and dry. If wood is kept perfectly dry, or, on the other hand, is kept constantly under water, it will last indefinitely without any sign of rot. For this reason piles should always be cut off below the water level. Decay takes place very rapidly when the wood is in a confined position, as when buried in a brick wall, so that the gases cannot escape. It is also hastened by warmth, and is much more common in the South than in the northern states. Decay may be prevented by introducing into the timber certain salts, such as the salts of mercury. It may also be prevented by heating the wood to a temperature above 150 degrees Fahrenheit and maintaining that temperature. All wood should be perfectly seasoned before being painted, and good ventilation should always be provided for. Wood should be especially protected whenever in contact with masonry from which it may absorb moisture.

Wet rot is a form of decay which takes place in the growing tree. It is caused by the tree becoming saturated with water, as in a swamp or bog, and it may be communicated from one piece of timber to another by contact.

Warping in timber is the result of the evaporation or drying out of the water which is held in the cell walls of the wood in its natural state, and the consequent shrinkage of the piece. If timber were perfectly regular in structure, so that the shrinkage would be the same in every part, there would be no warping; but wood is made up of a large number of fibers, the walls of which are of differ-

ent thickness in different parts of the tree or log, so that in drying one part shrinks much more than another. Since the wood is rigid, one part cannot shrink or swell without changing the shape of the whole piece, because the block as a whole must adjust itself to the new conditions; consequently the timber warps.

In Fig. 6, if the fibers in the top portion of the piece near the face *a b e* happen to have, on the average, thicker walls than those

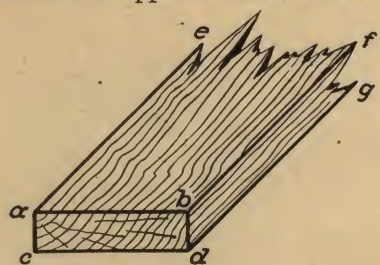


Fig. 6.

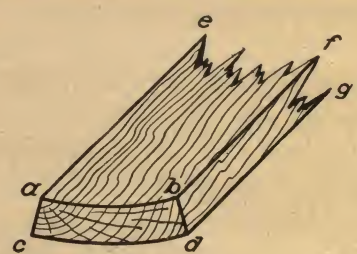


Fig. 7.

in the bottom portion, near the face *c d g*, the top part will shrink more than the bottom; the distance *a b*, originally equal to the distance *c d*, becomes smaller and the shape of the whole piece changes, as shown in Fig. 7.

The only way in which warping can be prevented is to have the timber thoroughly dried out before it is used. After it is once thoroughly seasoned it will not warp unless it is allowed to absorb more moisture. All wood that is to be used for fine work, where any warping after it is in place will spoil the appearance of the whole job, must be so seasoned, either in the open air or in a specially prepared kiln.

The wood of the "conifers," which is very regular in its structure, shrinks more evenly and warps less than the wood of the broad-leaved trees with its more complex and irregular structure. Sapwood, also, as a rule shrinks more than does heartwood.

Checks also are due to the uneven shrinkage of timber. In any log there is a chance for the wood to shrink in two directions — along the radial lines following the direction of the medullary rays, and around the circumference of the log, following the direction of the annual rings. If the wood shrinks in both directions at the same rate, the only result will be a decrease in the volume of the log, but if it shrinks more rapidly in one of these directions than it does in

the other, the log must crack around the outside as shown in Fig. 8. This cracking is called "checking," and is likely to take place. In timber which has been prepared for the market it shows itself in the form of cracks which extend along the faces of solid square timbers and boards, and seriously impairs the strength. Fig. 9 shows checks in a square post or column.

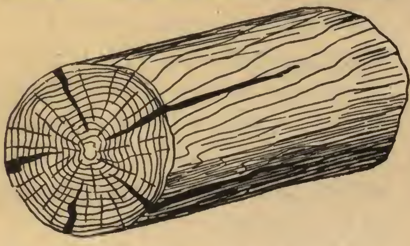


Fig. 8. Cracks Caused by Shrinkage.

Knots are very common in all timber. They are formed at the junction of the main tree trunk and a branch or limb. At such points the fibers in the main trunk, near the place where the branch comes in, do not follow straight along up the trunk, but are turned aside and follow along the branch as shown in Fig. 10. Frequently a branch may be broken off near the trunk while the tree is still young, and the tree continue to grow. The trunk will increase in size until the end of the branch, which was left behind buried in the main trunk, is entirely covered up. Meanwhile the end of the branch dies and a knot is formed. This bit of dead wood has no connection with the living wood about it. In time it works loose, and when the tree is sawed up into boards the knot may drop out. A knot does not seriously impair a piece subjected to a compressive stress, so long as it remains in place, but it greatly weakens a piece subjected to tension. A knot always spoils the appearance of any wood which is to be polished.

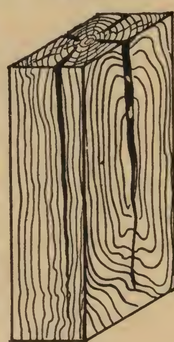


Fig. 9. Checks in Square Post.

Fig. 10. Knots.

TIMBER IN ITS COMMERCIAL FORM.

Conversion of Timber. Timber may be found in lumber yards in certain shapes ready for use, having been cut from the logs and relieved of the outside covering, or bark. There are various methods of cutting up the logs to form boards, planks and heavy timbers. If the log is to be squared off to form but

one heavy beam, a good rule to follow is to divide the diameter into three equal parts, and draw perpendiculars to the diameter at these points, one on each side of the diameter, as shown at A and B in Fig. 11. The points c and d in which these perpendiculars cut the circumference of the tree trunk, together with the points e and f in which the chosen diameter cuts the circumference of the tree trunk, will be the four corners of the timber. The lines joining these points will give an outline of the timber. This will be found to be the largest and best timber which can be cut from the log.

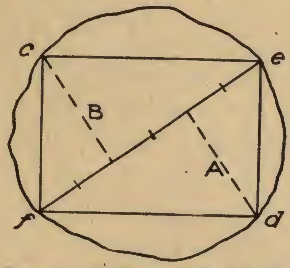


Fig. 11. Squaring off a Log.

Another good rule is to divide the diameter of the log into *four* equal parts and proceed in the same way as described above, using the outside quarter points on the diameter as shown in Fig. 12. This method will give a stiffer beam but it will not be so strong.

In Fig. 13 are shown several different methods of cutting planks from a log. First it is divided into quarters, and the planks are cut out as shown. The method shown at A, called "quarter sawing," is the best. All the planks are cut radiating from the center and there will be no splitting and warping. A fairly good method is that shown at B, where the planks are pretty nearly in radial lines and may be much more easily cut out than can those shown at A. The method shown at C is a common one and leads to fairly good results, although only the plank in the center is on a radial line. It is practically as good a method as that shown at B and is much more simple. The method shown at D is not so good as the others; planks cut in this way being very liable to warp and twist. If the silver grain, caused by the cutting of the medullary rays, is desired, the planks should be cut as at A or B.

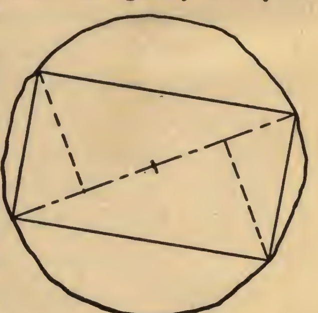


Fig. 12. Squaring off a Log.

Planks may sometimes be simply sliced from the log as shown in Fig. 14, without first dividing it into quarters. This is the worst possible way to cut them, as the natural tendency of the timber to

shrink causes the planks to curl up as shown in Fig. 15. It is almost impossible to flatten them out again and they cannot be used as they are.

VARIETIES OF TIMBER.

There are a great many different kinds of timber growing in the United States, and a considerable quantity is imported from other countries. Each variety possesses certain characteristics which render it especially suitable for use in one part of the building, while the same peculiarities of growth or of texture may unfit it for use in another place.

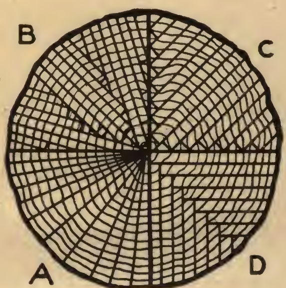


Fig. 13. Quarter Sawing.

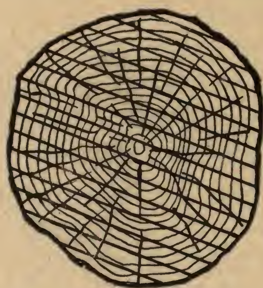


Fig. 14. Straight Sawing.

For timbers which are to be partly buried in the ground a wood is required which is able to withstand the deteriorating effects of contact with the earth; and for this purpose chestnut, white cedar, cypress, redwood or locust may be used.

For light framing we need a cheap, light wood free from structural defects such as knots and shakes, and which can be obtained in fairly long, straight pieces. Spruce, yellow pine, white pine and hemlock all satisfy these requirements fairly well, spruce being perhaps a little better than the others, and at any rate more popular.

For heavy framing, such as wooden trusses, girders and posts, we require a strong timber and one which can be obtained in large, long pieces. Georgia pine, Oregon pine and white oak may all be used for such work, and also Norway pine and Canadian red pine.


Fig. 15.

A wood which is easily worked and which will also withstand the effects of the weather is needed for the outside finish; for this we select white pine and

also cypress and redwood. The same woods are used for shingles, clapboards and siding, with the addition of cedar for shingles, and sometimes Oregon pine and spruce for siding.

For the interior finish is chosen a wood which will make a pleasing appearance, and which will take a polish; while for floors, hardness and resistance to wear are the further requirements. For floors, oak, hard pine, and maple are good; and for the rest of the interior finish, white pine, cypress and redwood, or any of the hard woods such as ash, butternut, cherry and mahogany, may be selected.

Some of the more important varieties of timber used in carpentry will now be mentioned, and a brief description of each kind given to convey an idea of its characteristics and the part of the country from which it comes.

EVERGREENS OR CONIFERS.

Cedar. There are five different kinds of white cedar in the United States, of which four are different species of the white cedar, and the fifth is what is known as "canoe" cedar. The wood is not very strong, but is light and soft, possessing considerable stiffness and a fine texture. In color it is grayish brown, the sapwood being, however, of a lighter shade than the heartwood. It seasons quickly, is very durable and does not shrink or check to any great extent. Its principal use in carpentry is for shingles, for which its durability makes it especially valuable, and for posts and ties. The trees are usually scattered among others of different kinds, forming occasionally, however, quite considerable forests. They are found all through the northern part of the country and on the Pacific coast in California, Oregon and Washington. Some of the trees are of medium size while others are very large, especially the canoe cedar in the Northwest.

In addition to the white cedars, there are the red cedars, which are similar to the others, but have a somewhat finer texture. There are two varieties, the red cedar and redwood, the former found principally in the southern states and the latter only in California. Red cedar is used but little in building construction except for cabinet work and veneers, but redwood has been used extensively in the West for outside finish, shingles and clapboards. Its resistance to

fire is remarkable, which makes it valuable for the exterior of dwellings, but it is too soft for interior finish.

Cypress. This wood is found in the southern states only, where it grows in the swamp land along the banks of the rivers. Although there are a great many varieties, they are similar in their general characteristics and differ only in quality. "Gulf cypress," growing near the Gulf of Mexico, is the best. The timber is light, straight-grained and soft, and is used for shingles and siding, water tables, sills and gutters. It does not warp and shows great resistance to dampness.

Hemlock. There are two varieties of hemlock, one found in the northern states, from Maine to Minnesota, and also along the Alleghanies, southward to Georgia and Alabama; and the other found in the West, from Washington to California, and eastward to Montana. The eastern tree is smaller than the western, and its wood is lighter and softer and generally inferior. The timber is of a light reddish-gray color, fairly durable, but shrinks and checks badly, and is rough, brittle, and usually cross-grained. It is sometimes used in the East for cheap framing, but it is so liable to imperfections such as windshakes and starshakes that it is not suitable for this purpose. It is often used for rough boarding or sheathing.

Spruce. There are three kinds of spruce — white, black, and red, of which the white spruce is the variety commonly found on the market. The wood is light and soft, but fairly strong, and is of a whitish color. It is much used in the northeastern states for light framing, but can be obtained only in small sizes. It is considered by many to be the best framing timber, excepting the pines.

The white spruce is found scattered throughout all of the northern states, along the streams and lakes, the largest varieties being in Montana.

The black spruce is found in Canada and in some of the northern states. It is distinguished from the other varieties only by its leaves and bark.

The red spruce is sometimes known as Newfoundland red pine and is found in the northeastern part of North America. Its wood is similar to the black spruce.

Pines. There are two distinct classes of pines used in building work, the soft and the hard pines, both of which are found in great

abundance scattered over the whole of the United States. The great variety of uses to which pine timber may be applied in building construction and the ease with which it can be cut and shipped to market, make it the most popular wood in use at the present time. The softer varieties are used for outside finishing of all sorts, and the harder kinds for heavy framing and for flooring. The tree itself is very tall, with a straight trunk and few branches, so that timbers can be obtained in large sizes and great lengths. There are many different kinds of pines, which are recognized in various parts of the country under various names, but there are five general classes into which the species is commonly divided, though the same timber may be called by different names in two different localities, as will be seen.

1. The term "hard pine" is used to designate any pine which is not white pine, and is a very general classification, though it is often met with in specifications and in works on Carpentry.

2. "White pine," "soft pine" and "pumpkin pine" are terms which are used in the eastern states for the timber from the white pine tree, while on the Pacific coast the same terms refer to the wood of the sugar pine.

3. The name "yellow pine" when used in the northeastern part of the country applies almost always to the pitch pine or to one of the southern pines, but in the West it refers to the bull pine.

4. "Georgia pine" or "longleaf yellow pine" is a term used to distinguish the southern hard pine which grows in the coast region from North Carolina to Texas, and which furnishes the strongest pine lumber on the market.

5. "Pitch pine" may refer to any of the southern pines, or to pitch pine proper, which is found along the coast from New York to Georgia and among the mountains of Kentucky.

Of the soft pines there are two kinds, the white pine and the sugar pine, the latter being a western tree found in Oregon and California, while the former is found in all the northern states from Maine to Minnesota. There is also a smaller species of white pine found along the Rocky Mountain slopes from Montana to New Mexico.

There are ten different varieties of hard pine, of which, however, only five are of practical importance in the building industry. These are the "longleaf southern pine," the "shortleaf southern pine," the "yellow pine," the "loblolly pine" and the "Norway pine."

The longleaf pine, also known as the "Georgia pine," the "yellow pine" and the "long straw pine," is a large tree, which forms extensive forests in the coast region from North Carolina to Texas. It yields very hard, strong timber which can be obtained in long, straight pieces of very large size.

The loblolly pine is also a large tree, but has more sapwood than the longleaf pine, and is coarser, lighter and softer. It is the common lumber pine from Virginia to South Carolina, and is also found in Texas and Arkansas. It is known as well by the name of "slash pine," "old field pine," "rosemary pine," "sap pine," and "short straw pine," and in the West as the Texas pine.

The shortleaf pine is much like the loblolly pine and is the chief lumber tree of Missouri and Arkansas. It is also found in North Carolina and Texas.

The Norway pine is a northern tree found in Canada and the northern states. It never forms forests, but is scattered among other trees, and sometimes forms small groves. The wood is fine-grained and of a white color, but is largely sapwood and is not durable.

BROAD-LEAVED TREES.

Ash is a wood that is frequently employed for interior finishing in public buildings, such as schoolhouses, and in the cheaper classes of dwelling houses. It is one of the cheapest of the hard woods; it is strong, straight-grained and tough, but is coarse in texture. It shrinks moderately, seasons with little injury, and will take a good polish. The trees do not grow together in forests, but are scattered. They grow rapidly, and attain only medium height. Of the six different species found in the United States, only two, the "white ash" and the "black ash," are used extensively in building work. The first is more common in the basin of the Ohio River, but is also found in the North from Maine to Minnesota, and in the South, in Texas. The black ash is found from Maine to Minnesota, and southward to Virginia and Arkansas. There is very little difference between the two species. The black ash is also known as the "hoop ash" and the "ground ash."

Beech. Another wood used to some extent for inside finish is the beech. It is heavy, hard and strong, but of coarse texture like the ash. In color it is light brown, or white. It shrinks and checks

during the process of drying and is not durable when placed in contact with the ground. It works easily, stands well, and takes a good polish.

Birch is a very handsome wood of a brown color and with a satiny luster. It takes a good polish, works easily, and does not warp after it is in place, but it is not durable if exposed. It is used quite extensively for inside finish, and to imitate cherry and mahogany, as it has a grain which is very similar to the grain of these woods. The trees are of medium size and form large forests. They are found throughout the eastern part of the United States.

Butternut is also used as a finishing wood, and is cheaper than many of the other harder woods. It is light, but not strong, and is fairly soft. In color it is light brown. The trees, of medium size, are found in the eastern states from Maine to Georgia.

Cherry is a wood which is frequently used as a finishing wood for the interior of dwellings and of cars and steamers ; but owing to the fact that it can be obtained only in narrow boards, it is most suitable for moulded work, and work which is much cut up. The wood is heavy, hard, strong and of fine texture. The heartwood is of a reddish brown color, while the sapwood is yellowish white. It is very handsome and takes a good polish, works easily and stands well. It shrinks considerably in drying. The timber is cut from the wild black cherry tree, which is of medium size and found scattered among the other broad-leaved trees along the western slope of the Alleghanies and as far west as Texas.

Chestnut timber is used in cabinet work, for interior finishing, and sometimes for heavy construction. It is light, fairly soft, but not strong. It has a rather coarse texture, works easily and stands well, but shrinks and checks in drying. The timber is very durable. The tree grows in the region of the Alleghanies, from Maine to Michigan, and southward to Alabama.

Elm. There are five species of elm trees in the United States, scattered throughout the eastern and central states. The trees are usually large and of rapid growth, and do not form forests. The timber is hard and tough, frequently cross-grained, hard to work, and shrinks and checks in drying. The wood has not been used very extensively in building, but has a beautiful figured grain, can take a high polish, and is well adapted to staining. The texture is coarse to fine, and the color is brown with shades of gray and red.

Gum. The wood of the gum tree is used extensively for cabinet work, furniture, and interior finish. It is of fine texture and handsome appearance, heavy, quite soft, yet strong, and reddish brown in color. It warps and checks badly, is not durable if exposed, and is hard to work. The species of gum tree used in carpentry is the sweet gum, which is of medium size, with straight trunk; it does not form forests, though it is quite abundant east of the Mississippi River.

Maple. Almost all of the maple used in building work comes from the sugar maple tree, which is most abundant in the region of the Great Lakes, but which is also found from Maine to Minnesota, and southward to Florida. The trees are of medium to large size, and form quite considerable forests. The wood is heavy and strong, of fine texture, and often has a fine wavy grain which gives the effect known as "curly." It is of a creamy white color, shrinks moderately, works easily and takes a good polish. It is often used for flooring, and sometimes for other inside finish.

Oak. There are about twenty different kinds of oak to be found in various parts of the United States, but there are three distinctly different species, which are sold separately. These are the "white oak," the "red oak" and the "live oak." The red oak is usually more porous, less durable and of coarser texture than the white oak or the live oak. The trees are of medium size and form a large proportion of all the broad-leaved forests. Live oak was once extensively used, but has become scarce and is now expensive. Both the red oak and the white oak are used for inside finishing, but they are liable to shrink and crack and must therefore be thoroughly seasoned. They are of slightly different color, the white oak having a straw color while the red oak has a reddish tinge, so that they cannot be used together where the work is to be finished by polishing. Oak is always better if quarter-sawed, when it shows what is known as the "silver grain."

Poplar. This wood is also known as "whitewood" and "tulip wood." There are a number of different varieties growing in various parts of the country. The tree is large, and is most common in the Ohio Basin, but does not form forests. The wood is light, soft, free from knots, and of fine texture. In color it is white, or yellowish-white, and frequently it has a satiny luster. It can be so finished as to retain its natural appearance, but it is often stained to imitate

some of the more costly woods, such as cherry. It is used extensively for cheap inside finish and fittings, such as shelving, and sometimes for doors, but it warps badly if it is not thoroughly seasoned.

Sycamore is frequently used for finishing, and is a very handsome wood. It is heavy, hard, strong, of coarse texture, and is usually cross-grained. It is hard to work, and shrinks, warps, and checks considerably. The tree is of large size and rapid growth, found in all parts of the eastern United States, but is most common along the Ohio and Mississippi Rivers.

Black Walnut is a wood which has been and is still used very extensively for interior finishing and in the manufacture of furniture. It is a heavy, hard timber, of coarse texture, and of a dark-brown color. Very handsome pieces having a beautiful figure, may be selected for veneers for furniture and cabinet work. Although the wood shrinks somewhat in drying, it works easily, stands well, and will take a very good polish. The tree is large and of rapid growth. It was formerly very abundant in the Alleghany region, and was found from New England to Texas and from Michigan to Florida, but it is now becoming scarcer and the timber is expensive.

Imported Timber. Besides the woods which grow in the United States, a number of others are brought in from foreign lands for use in the best grade of public buildings and private residences. The most popular of these are the mahogany, rosewood, satinwood, French burl, and Circassian walnut.

Mahogany comes from Cuba and Mexico, and formerly was obtained also from Santo Domingo and Honduras. It is generally imported in the rough log and cut up by the purchasers as it is required. The wood is easy to work, will take an excellent polish, and stays in place very well if it is well seasoned. It varies in color from very light to deep red and becomes darker with age. It is usually employed in the form of veneers on account of its cost.

Satinwood comes from the West Indies, French burl from Persia, and Circassian walnut from near the Black Sea. They are all very expensive and are used only as veneers, and in only the finest work.

GENERAL CHARACTERISTICS OF TIMBER.

In speaking of wood we are accustomed to use certain words to express our idea of its mechanical properties, or of its probable

behavior under certain conditions. Thus we say that a wood is hard, or tough, or brittle, or flexible, and frequently we use these terms without having a clear understanding of just what they mean. A very brief discussion of some of these properties or characteristics of timber will now be given in order that we may see what peculiarities of structure or of growth cause them.

Hardness. If a block of wood is struck with a hammer when lying on a bench, the hammer-head will make an impression or dent in the wood, which will be deeper or shallower according as the wood is soft or hard. A wood is said to be very hard when it requires a pressure of about 3,000 pounds per square inch to make an impression one-twentieth of an inch deep. A hard wood requires only about 2,500 pounds to produce the same effect. Fairly hard wood will be indented by a pressure of 1,500 pounds, and soft woods require even less. Maple, oak, elm and hickory are very hard; ash, cherry, birch and walnut are hard; the best qualities of pine and spruce are fairly hard; and hemlock, poplar, redwood and butternut are soft.

Toughness. "Toughness" is a word which is often used in relation to timber, and implies both strength and pliability, such as is found in the wood of the elm and hickory. Such timber will withstand the effect of jars and shocks which would cause other woods, like pine, to be shattered.

Flexibility. Timber is said to be flexible when it bends before breaking instead of breaking off short, or, in other words, a flexible wood is the opposite of one which is brittle. The harder woods, taken from the broad-leaved trees, are usually more flexible than the softer woods, taken from the cone-bearing trees. The wood of the main tree trunk is more flexible than that of the limbs and branches, and moist timber is more flexible than dry wood. Hickory is one of the most flexible woods.

Cleavage. Most woods split very easily along the grain, especially when the arrangement of the fibers is simple, as in the conifers. In splitting with an axe, the axe-head acts as a wedge and forces the fibers apart, and usually the split runs along some distance ahead of the axe. Hard woods do not split so easily as soft woods, and seasoned wood not so easily as green wood, while all timber splits most easily along radial lines.

THE STEEL SQUARE.

If it is important that a workman should know his material thoroughly, it is even more essential that he should understand his tools and be able to apply them in the most useful way to any particular piece of work. This is especially true of the tool known as the "Carpenter's Steel Square" which is without doubt the most useful of all the tools to be found in a carpenter's chest, but which is not always thoroughly understood even by experienced workmen. As the square will be referred to frequently in these pages a brief description of it will be given.

12ths

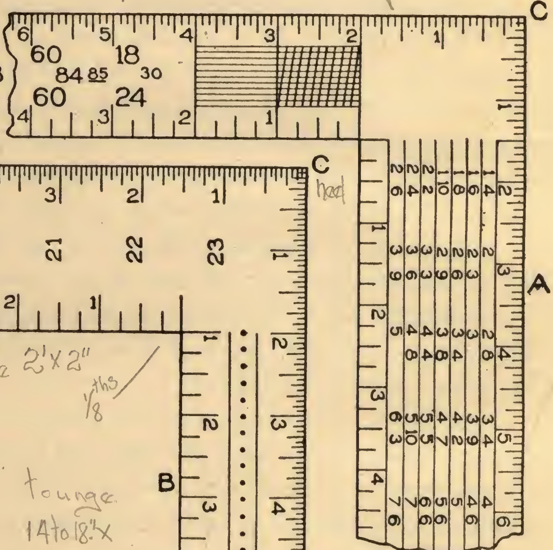
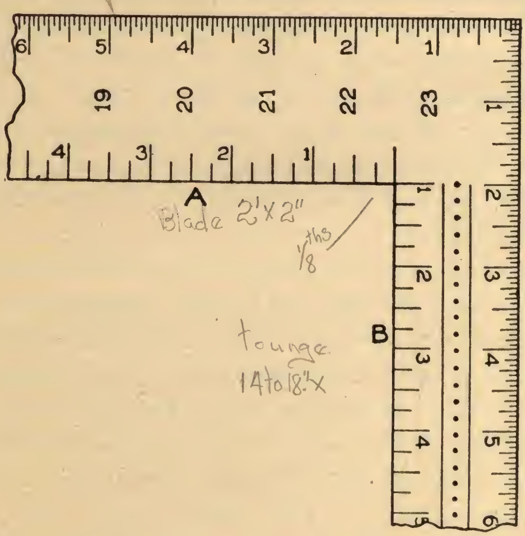


Fig. 17.

16ths



head

Blade 2'x2"

1/8 ths

tounge 14to18"x

Fig. 16. Carpenter's Steel Square.

It is shown in Figs. 16 and 17, each view showing one side of the square. It is essentially a measuring and calculating tool, and all of the various markings and scales found on either side have their own special uses. All squares are not alike, there being several kinds on the market and in daily use among mechanics, but the

variations in the markings on the different squares are so slight that if one is explained the others can be readily understood.

There are three parts to the tool which are distinguished by special names, the tongue, the blade and the heel. The longer, wider arm is called the blade; the shorter, narrower arm is called the tongue; and the point in which the tongue and the blade meet, on the outside edge of the square, is called the heel. In the figures, A is the blade, B the tongue, and C the heel. In carefully made tools, the blade is two feet long and two inches wide, while the tongue is from fourteen to eighteen inches long and one and one-half inches wide.

Starting at the heel and reading away from it, the outside edges of the blade and the tongue on both sides of the square, are divided into inches and fractions of an inch, one side of the square showing sixteenths and the other side showing twelfths. Starting at the interior angle opposite the heel, the inside edges are divided in a similar way except that the inches on both sides of the square are divided into eighths only. In some squares one of these scales is shown divided into thirty-seconds of an inch. On one side of the blade the inch marks are numbered in both directions, from the heel outward, and also from the end of the blade inward, toward the heel, so that each inch mark has two numbers, one showing its distance, in inches, from the heel, and the other showing its distance from the end of the blade. These extra numbers are very useful in measuring the depth of mortises and in all similar work. The arrangement is shown in Fig. 16.

On the other side of the blade, which is shown in Fig. 17, in addition to the scales on the two edges, we find a column of figures directly under each of the inch marks on the outer edge. The figures are arranged in eight rows, parallel to the edges of the square, and the rows are marked off by lines running the full length of the blade. These figures enable a man to tell at a glance the number of board-feet in a piece of timber whose dimensions he knows. Under the twelve-inch mark there are figures showing the different lengths which can be measured in this way, so that each row of figures corresponds to a certain length, found under the twelve-inch mark. Under each of the other inch marks there are figures, each of which gives the number of board-feet in a plank one inch thick, whose

width in inches is indicated by the number of the inch marks under which the figure is found, and whose length, in feet, is indicated by the number found in the same row with the figure itself under the twelve-inch mark. There are seven or eight different lengths given, and twenty-three different widths for each length, the widths varying from two inches up to twenty-four inches. The figures expressing the board measure are given as feet and inches, the number of feet being separated from the number of inches by a vertical line, with the feet on the left and the inches on the right. For instance, 11 8 is read as eleven feet and eight inches.

On the same side of the square which shows the board measure on the blade, we find on the tongue what is known as the "brace rule," placed in the middle of the tongue between the two scales which are marked off along the edges. The brace rule consists of two similar numbers representing length in feet, placed one above the other, with a third number placed just to the right of them, as $\begin{smallmatrix}24\\24\end{smallmatrix}$ 33.94. The two similar numbers represent the length, in feet, of the side of a perfect square, and the third number represents the length of the diagonal of this square, expressed in feet and decimals of a foot. In other words the number to the right is equal to the square root of the sum of the squares of the other two numbers, or is equal to one of these numbers multiplied by the square root of 2, which is 1.414, in accordance with the principle that the length of the diagonal of a square is equal to the length of the side multiplied by the square root of two. There are a number of different sets of figures like this on the tongue of the square; they are very useful in finding the length of braces which make an angle of forty-five degrees with the post into which they frame, or which have a total rise equal to their total run.

On the same side of the tongue which shows the brace rule, placed near the heel of the square, is found another scale which may be called the "Scale of Hundredths." It consists of a number of lines drawn along the tongue parallel to the edges, which are just one-tenth of an inch apart.

They are drawn diagonally, so that the end of one line is directly under the starting point of the next line. By means of this scale any number of hundredths of an inch can be readily measured off. The scale may be seen in Fig. 17.

The opposite side of the square shows two lines, drawn near together in the center of the tongue. Parallel to the edges and between these lines a single line of dots is placed. They are a little more than one-fifth of an inch apart and numbered by tens. The dots constitute what is called the "octagon scale," and are used in the process of cutting a stick of octagonal section out of a stick of square section. Suppose for example we take a stick ten inches square and wish to cut from it a stick of octagonal section. We will first draw a line lengthwise in the center of each of the four faces of the square stick. Then applying the square, we measure off on both sides of this center line, in each face, perpendicular to the edges of the piece, as many of the spaces shown by the line of dots as there are inches in the side of the square stick. Thus in this case, we measure off ten spaces on each side of each center line, and then draw through the points thus located two lines in each face, parallel to the center line and equidistant from it. These eight lines represent the eight edges of the octagonal stick, and by cutting away the four corners, the desired shape is obtained.

This completes the description of the markings upon the square, and although there are undoubtedly some squares in use which may not be exactly like the model described, they all have nearly the same markings, arranged in the same way or with but slight variations.

Some of the numerous applications of the square in the solution of practical problems in Carpentry are explained in connection with the work on "framing," and others will suggest themselves to the thoughtful student. The uses to which the instrument may be put are so many and so various that it would require a large book to explain them all, but those who use the tool constantly will readily discover them and perhaps many new ones besides.

LAYING OUT.

Having now considered the material and the most important of the tools with which the carpenter performs his work, we shall pass to a consideration of the work itself, and see how a building of wooden construction is put together.

In undertaking the construction of any building, the first thing to do is to make a very thoughtful examination of the piece of ground upon which the structure is to be placed. This is very important,

since the character of the soil upon which a dwelling is located will very largely determine its sanitary condition, and will influence to a great extent the health of the occupants. Very often a difference of a few yards in the position of a building will be enough to cause the difference between a perfectly dry cellar and one which is constantly flooded with water. Water is, indeed, the one thing above all others which must be guarded against, since it is almost impossible to keep it out of a cellar which is sunk in damp ground.

At a certain distance below the surface of the earth there is always to be found what is known as "ground water." This stands always nearly at a level, so that it is not met with so near the surface of a slight knoll or other elevation as in the case of a depression. If possible, the house should be so located that the bottom of the cellar need not come below the ground-water level, and consequently it should be placed on comparatively high land. Below the surface of a hill, however, there may be a stratum of rock which will hold the rain water and prevent it from sinking at once to the ground-water level. Such a ledge of rock causes the water to collect, and then flow off in small subterranean streams, which will almost surely penetrate the walls of a cellar if it happens to be in their path.

A good way to discover the depth of the ground-water level, or the existence of rock ledges beneath the surface of the ground, is to dig a number of small, deep holes at various points of the site. These should be carried below the proposed level of the cellar bottom. A suitable location for the building may thus be chosen.

When the approximate position of the structure has been decided upon, the next step is to "stake it out." That is, the position of the corners of the building must be located and marked in some way on the ground, so that when the excavation is begun the workmen may know what are the exact boundaries of the cellar. This "staking out" should always be carefully attended to, no matter how small the building may be. In works of importance it is always best to have the work done by an engineer, but on small work it is customary for the contractor or the architect to attend to it. It is well to have at hand some instrument with which angles can be accurately measured, such as a transit; but the work can be done very satisfactorily with a tape measure and a "mason's square." This simple instrument is composed of three sticks of timber nailed together as shown in Fig.

18, to form a right-angled triangle. It is important that the tape used should be accurate, a steel tape being always preferable, and that the square should give an exact right angle. A mistake in the staking out may cause endless trouble when the erection of the building itself is begun, and it is then too late to remedy it.

There are several different lines which must be located at some time during the construction, and they may as well be settled at the start. These are: the line of excavation, which is outside of all; the face of the basement wall, inside of the excavation line; and, in the case of a masonry building, the ashlar line, which indicates the outside of the brick, or stone walls. In the case of a wooden structure only the two outside lines need be located, and often only the line of the excavation is determined at the outset.

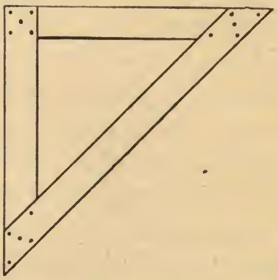


Fig. 18. Mason's Square.

The first thing to do is to lay out upon the ground the main rectangle of the building, after which the secondary rectangles which indicate the position of ells, bay windows, etc., may be located. Starting at any point on the lot where it is desired to place one corner of the building, a stake should be driven into the ground and a line laid out either parallel or perpendicular to the street upon which the structure is to face. At the end of this line, which forms one side of our rectangle, and the length of which is determined by the dimensions of the building, another stake should be driven, and these two stakes will determine the direction and the length of the line. The exact location of the ends of the line may be indicated by a nail driven into the top of each stake.

After one line has been thus laid out, others may be laid out perpendicular to it at its ends, with the aid of the mason's square and the tape measure. The accuracy of the right angle may be checked by the use of the "three-four-five" rule. This rule is based upon the fact that a triangle, whose three sides are respectively three, four, and five feet long, is an exact right-angled triangle, the right angle being always the angle between the three-foot and the four-foot sides. This fact may be proven by applying the well-known theorem which states that the length of the hypothenuse of

a right-angled triangle is equal to the square root of the sum of the squares of the other two sides. The rule may be used as follows :

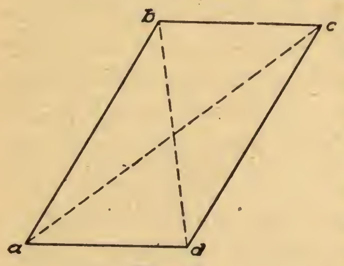


Fig. 19.

Lay off on one of the side lines already laid out on the ground, any multiple of three feet, as nine feet, or twelve feet. On the other line, presumably at right angles to the first one, lay off the same multiple of four feet, as twelve feet, or sixteen feet. Now a straight line, measured between the points so obtained, should have a length equal to the same multiple of five feet, as fifteen feet or twenty feet. If this is not found to be the case, the angle laid out is not an exact right angle, and instead of a rectangle we have a parallelogram as shown in Fig. 19. This will not do at all, and the inaccuracy must be corrected. It is possible to lay out the right angle in the first place by this same method, using two flexible cords, respectively four feet and five feet long. The end of the four-foot cord should be fastened at the end of the side line of the building, and the end of the five-foot cord should be fastened on this same side line, three feet away from the corner. When the loose ends of both cords are held together, and the cords are both drawn taut, the point where the ends meet will be a point on the side line of the building perpendicular to the first side line. It is evident that this point must be just four feet from the corner, and that the distance between it and the point on the other side line, three feet from the corner, must be five feet.

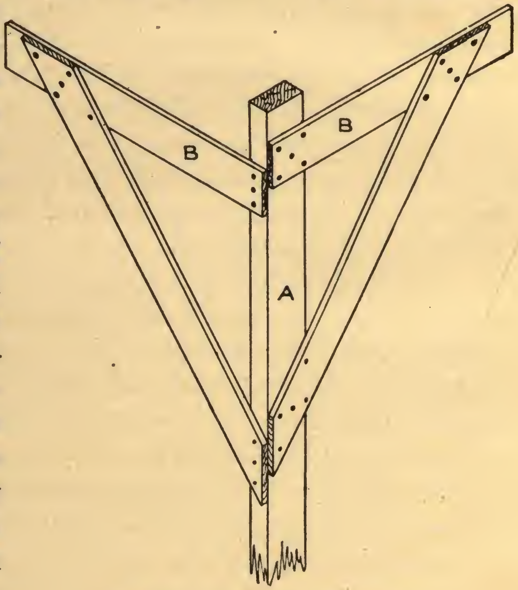


Fig. 20. Position of Corner.

After all the corners of the building have been located, their position should be indicated by the use of "batter boards." One of these is shown in Fig. 20. It will be seen that it consists of a post A, which is set up at the corner, together with two horizontal pieces B, B, which extend outward for a short distance along the sides of the rectangle that has been laid out. The horizontal pieces may be braced securely as shown, and the whole will be a permanent indication of the position of the corner. Notches may be cut in the top of the horizontal pieces to indicate the position of the various lines, and cords may then be stretched between the notches from batter board to batter board. These cords will give the exact location of the lines.

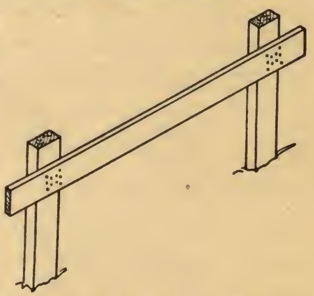


Fig. 21. Batter Boards.

Another way to indicate the position of the lines is by driving small nails into the tops of the batter boards instead of cutting notches in them; but nails may be withdrawn, while the notches, when they are once cut, cannot easily be obliterated.

Batter boards should always be set up very securely, so that they will not be displaced during the building operations. If there is danger that the form of batter board shown in Fig. 20 may be displaced, because of the large size of the structure and the length of time during which they must be used, the form shown in Fig. 21 may be substituted. Two of these, at right angles to each other, must be placed at each corner.

LIGHT FRAMING.

After the building has been laid out, and the batter boards are in place, the next work which a carpenter is called upon to do is the framing. This consists in preparing a skeleton, as we may say, upon which a more or less ornamental covering is to be placed. Just as the skeleton is the most essential part of the human body, so is the frame the most essential part of a wooden building; and upon the strength of this frame depends the strength and durability of the structure. When the carpenter comes to the work, he finds everything prepared for him; the cellar has been dug and the

foundation walls and the underpinning have been built. It is his business to raise the framework on top of them. First is the wall, then the floors and the roof. Therefore the subject may be subdivided, and considered under these three main headings. In connection with the walls we may consider the partitions as well as the outside walls, and in connection with the floors we may consider the stairs, while the roof may be taken as comprising the main roof and also subordinate roofs over piazzas, balconies and ells. This covers all the framing that will be found in a wooden building, except special framing, which will be treated later. Whatever framing there is in a brick or stone building is similar to that in a wooden building, with the slight differences which may be noted as we come to them.

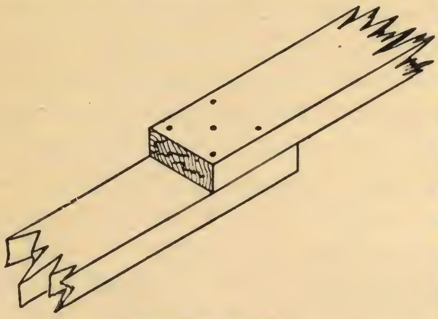


Fig. 22. Splice.

JOINTS AND SPLICES.

Joints. Before beginning a description of the framing of the wall, it will be well to consider the methods employed in joining pieces of timber together. The number of different kinds of connections is really very small, and the principles upon which they are based may be mastered very quickly.

All connections between pieces of timber may be classified as joints or as splices. By a "splice" we mean a connection between two pieces which extend in the same direction, as shown in Fig. 22, and each one of which is merely a continuation of the other. The only reason for the existence of such a connection is the fact that sticks of timber can be obtained only in limited lengths, and must therefore very often be pieced out. By a "joint" we mean any connection between two pieces which come together at an angle, as

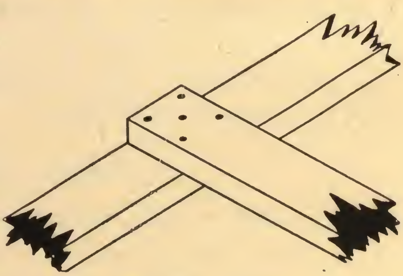


Fig. 23. Joint.

shown in Fig. 23, and which are therefore not continuous. Such a connection may be required in a great many places, and especially at the corners of a building.

6 **Joints.** The principal kinds of joints to be met with in carpentry are the "butt joint," the "mortise-and-tenon joint," the "gained joint," the " halved joint," the "tenon-and-tusk joint," and the "double tenon joint."

1 **The Butt Joint.** This is the most simple of all the joints, and is made by merely placing the two pieces together and nailing them firmly to each other, after both have been trimmed square and true. Such a joint is shown in Fig. 24. The two pieces are perpendicular to each other and neither piece is cut. The nails are driven diagonally through both pieces, an operation which is known as "toe-nailing," and are driven home, if necessary, with a nail set. This is called a "square" butt joint. Fig. 25 shows two pieces which are not perpendicular to each other. They are trimmed to fit closely together, and are then nailed in place. Such a joint is called an "oblique" butt joint. The butt joint does not make a strong connection between the pieces, and should not be used if much strength is required. It depends entirely upon the nails for its strength, and these are very likely to pull out.

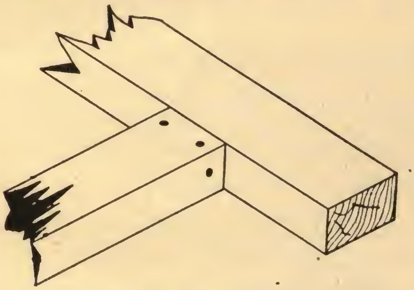


Fig. 24. Butt Joint.

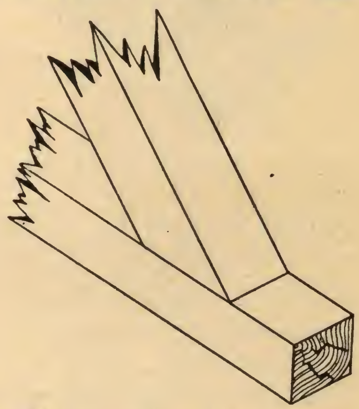
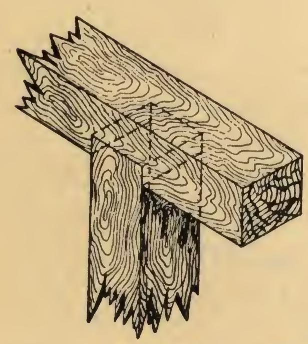


Fig. 25. Oblique Butt Joint.

This form of joint is sometimes modified by cutting away a part of one of the pieces, so that the other may set down into it as shown in Fig. 26, the square joint at A, and the oblique joint at B. This gives much additional strength to the joint, especially in the case shown at B, where there may be a tendency for one piece to slide along the other.

2 **The Mortise-and-Tenon Joint.** From the modified butt joint it is only a step to the "mortise-and-tenon" joint, which is formed by cutting a hole called a "mortise" in one of the pieces of timber, to receive a projection called a "tenon" which is cut on the end of the other piece. This is shown in Fig. 27. The mortise is at *a* and the tenon at *b*. It will be noticed that there is a hole bored



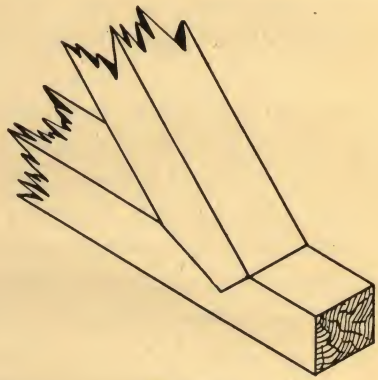


Fig. 26 A. **Modified Butt Joints.** Fig. 26 B.

through the tenon at *c*, and another hole in the mortised piece at *d*. These holes are so placed that when the pieces are joined together, a wooden pin may be driven through both holes, thus preventing the tenon from being withdrawn from the mortise. This pin should *always* be inserted in a mortise-and-tenon joint. Ordinarily it is of hard wood even when the pieces to be joined are themselves of soft wood, and it may be of any desired size. Round pins from three-quarters to seven-eighths of an inch in diameter are ordinarily employed, although it may sometimes be found better to use a square pin.

The Bridge Joint. The form of mortise-and-tenon joint described above may be used wherever the pieces are perpendicular to each other. When, however, the pieces are inclined to each other, a modification of the above joint known as the "bridge" or "straddle" joint is employed. This joint is shown in Figs. 28 and 29. It is similar to the square mortise-and-tenon joint, having a similar mortise and tenon, but these are cut in a slightly different way. In Fig. 28 the tenon *a* is cut in the end of the inclined piece and fits into the mortise *b* cut in the other piece.

In Fig. 29 the mortise *a* is cut in the end of the inclined piece and the tenon *b* is cut in the other piece.

The Gained Joint. The joints which have so far been described are applicable only where the members are subjected to

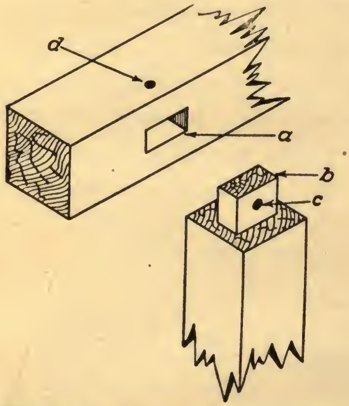


Fig. 27. Mortise-and-Tenon Joint.

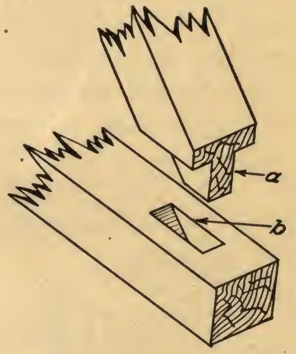


Fig. 28. Bridge Joint.

direct compression, as in the case of posts or braces, or in certain cases where direct tension is the only force acting on the pieces. When bending and shearing are to be expected, as in the case of

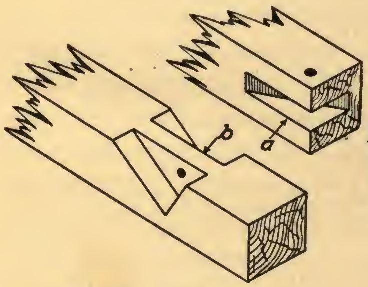


Fig. 29. Bridge Joint.

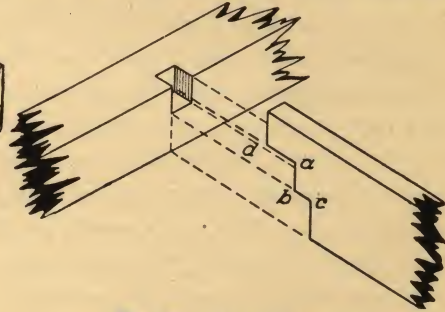


Fig. 30. Gained Joint.

floor beams connecting to sills or girders, a slightly different sort of joint must be employed.

One of the most common joints for such places is a modification of the mortise-and-tenon joint which is known as the "gained joint." An example of this form of connection is shown in Fig. 30, and it may be seen that the end of one piece is tenoned in a peculiar way. The tenon proper is the part *a-b-c* and this tenon

sets into a corresponding mortise cut in the other piece as shown. It is evident that the tenon cannot be held in place by a pin, but it may be secured by nailing.

The reason for this peculiar form of tenon may be explained as follows: A floor beam, or any other timber which is loaded transversely, has a tendency to fall to the ground, and must be supported at its ends either by resting directly on a wall or sill, or by being mortised into the latter member. Moreover, in order that the end of the piece resting on the support may not be crushed or broken, a certain amount of bearing surface must be

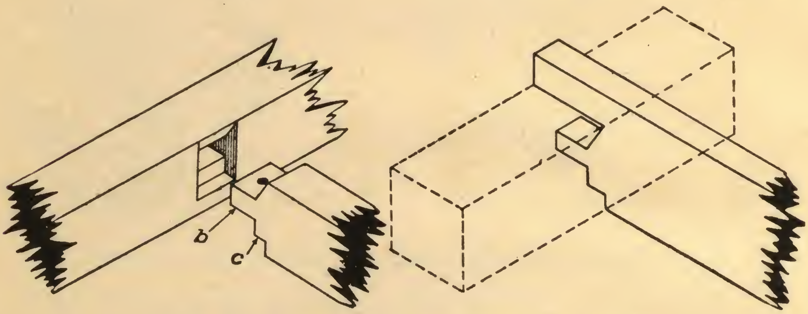


Fig. 31. Tenon-and-Tusk Joints. Fig. 32.

available. This same bearing surface must be provided in every case no matter whether the timber rests directly on the top of the sill or is mortised into it. Of course the simplest connection is obtained by resting the transverse piece directly on top of the sill without cutting either piece; but such a joint is not stiff and strong, and it is often necessary to bring the timbers flush with each other at the top or at the bottom. For this reason a mortised joint is used; and in order to obtain the required amount of bearing surface without cutting the pieces too much, the form of tenon shown is employed. The available bearing area here is furnished by the surfaces *d-a* and *b-c* and it may easily be seen that this area is the same as would be available if the piece rested directly on top of the sill.

The operation of cutting such a tenon and mortise is known as "gaining," and one piece is said to be "gained" into the other.

The Tenon-and-Tusk Joint. A joint in very common use

in such situations as have just been mentioned is a development of the gained joint which is called the "tenon-and-tusk" or the "tusk-tenon" joint. This joint is shown in Fig. 31. The characteristic feature is to be found in the peculiar shape of the tenon which is cut in the end of one of the pieces to be joined, as shown in the figure. It may be seen that there is a small square tenon *b* cut in the extreme end of the piece, and that in addition to this there are other cuts *c* which constitute the "tusk." The bearing area is furnished partly by the under side of the tenon and partly by the under side of the tusk.

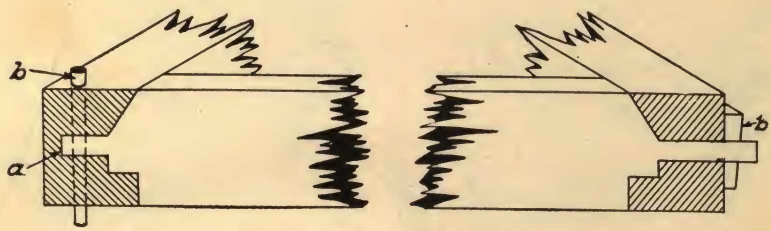


Fig. 33. Methods of Securing Tenons. Fig. 34.

This joint makes a very good connection, and the cutting of the mortise does not weaken the piece of timber so much as does the mortise for a gained joint. It is especially applicable when it is desired to have the pieces flush on top, though it may also be used in other positions. When the top of the tenoned piece must project above the top of the mortised piece, the tenon may be cut as shown in Fig. 32.

There are several ways of securing the tenon in place. The simplest is that shown in Fig. 33, where the pin *b* is passed through the tenon and the mortised piece so as to hold the tenon securely in place. Another scheme is to cut the square tenon a little longer, as shown in Fig. 34, so as to pass clear through the mortised piece, and to fasten it with a peg *b* on the other side. The peg may be cut slightly tapering, as shown, so that when it is driven in place it will draw the pieces together. Still another plan is shown in Fig. 35. Here a small square hole *a* is cut in the header some

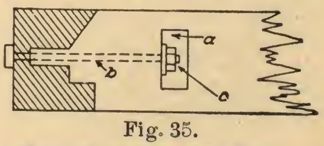


Fig. 35.
Method of Securing Tenon.

distance back from the tenon and a nut *c* is placed in it, while a bolt *b* is passed through a hole bored lengthwise in the header to receive it. The bolt passes through the nut, which may be screwed up tight, thus drawing the pieces closely together and making the joint tight. In screwing this up, it is the bolt which must be turned, while the nut is held stationary by the side of the square hole in which it is inserted and which is just large enough to receive it.

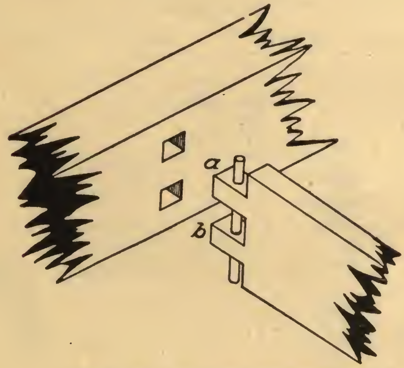


Fig. 36. Double Tenon Joint.

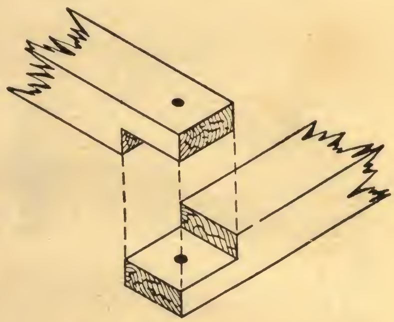


Fig. 37. Halved Joint.

The Double Tenon Joint. Fig. 36 shows a form of tenon joint called the "double tenon" joint, which is not very extensively used at the present time but which has some advantages. As may be readily seen, there are two small tenons *a* and *b* through which a pin may be passed if desired.

The Halved Joint. A form of joint which may be used to connect two pieces that meet at a corner of a building, is shown in Fig. 37.

This is known as the "halved" joint from the fact that both pieces are cut half way through and then placed together. The pieces are held in place by nails or spikes.

If one piece meets the other near the center instead of at the end of the piece, and if there is danger that the two pieces may pull away from each other, a form of joint called the "dovetail" halved joint is used. This is shown in Fig. 38. Both the tenon and the mortise are cut in the shape of a fan, or dovetail, which prevents them from being pulled apart. This joint may also be

cut as shown in Fig. 39, with the flare on only one side of the tenon, the other side being straight.

Splices. As already explained, a splice is merely a joint between two pieces of timber which extend in the same direction, and is sometimes necessary because one long piece cannot be conveniently or cheaply obtained. The only object in view, then, is

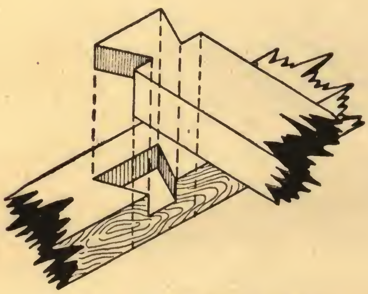


Fig. 38. Dovetail Halved Joint.

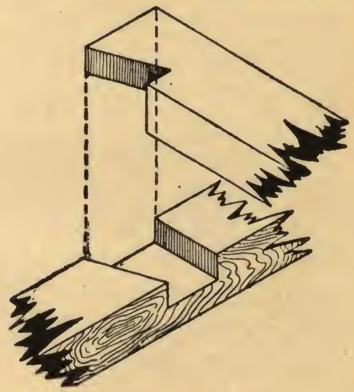


Fig. 39. Dovetail Joint.

to fasten the two timbers together, in such a way that the finished piece will be in all respects equivalent to a single unbroken piece, and will satisfy all the requirements of the unbroken piece. This is really the only measure of the efficiency of a splice.

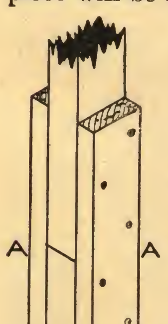


Fig. 40. Fished Splice.

There are three kinds of forces to which a piece may be subjected, namely: compression, tension, and bending. A splice which would be very effective in a timber acted upon by one of these forces might be absolutely worthless in a piece which must resist one of the other forces. We have, therefore, three classes of splices, each designed to resist one of these three forces.

Splices for Compression. The simplest splices are those to resist compression alone, and of these the most simple is that shown in Fig. 40. This piece is said to be "fished;" the two parts are merely sawed off square and the ends placed together. A couple of short pieces A A, called "fish plates" are

nailed on opposite sides to keep the parts in line. In the splice shown in Fig. 40, these are of wood, and ordinary nails are used to fasten them in place, but in more important work thin iron plates are used, the thickness being varied to suit the conditions. They are held in place by means of bolts with washers and nuts.

If for any reason, it is desired not to use plates of this kind, four small pieces called dowels may be used, as indicated in Fig. 41. These dowels may be set into the sides of the timbers to be spliced, so that they do not project at all beyond the faces of these pieces and a very neat job may thus be obtained.

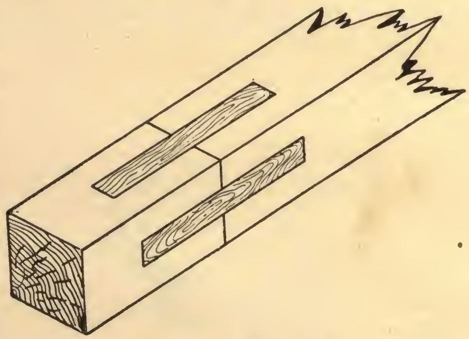


Fig. 41. Splice Using Dowels.

It is but a step to pass from this simple splice to the "halved" splice shown in Fig. 42. It will be noticed that it is much like the halved joint described above, the only difference being that the pieces are continuous, instead of perpendicular to each other. The nature of the splice will be easily understood from the figure

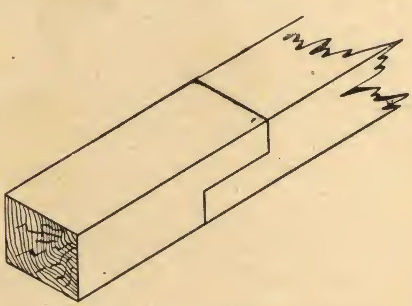


Fig. 42. Halved Splice.

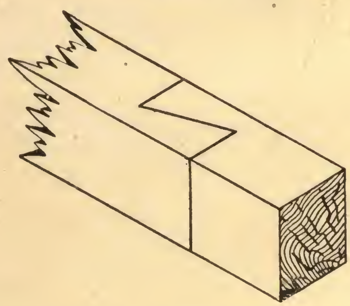


Fig. 43. Beveled Splice.

without further explanation. A modification of this which is somewhat more effective, is shown in Fig. 43. The cuts are here made on a bevel in such a way that the parts fit accurately when placed together, and the splice is called a "beveled" splice.

The halved splice is perhaps the best that can be used to

resist direct compression, and when it is combined with fish plates and bolts as shown in Fig. 44 it may be used in cases where some tension is to be expected. It will be noticed that in Fig. 44 the ends of the timbers are cut with a small additional tongue *a* but this does not materially strengthen the splice and it adds considerably to the labor of forming it. In general it may be said that the simplest splice is the most effective.

Whenever the pieces are cut to fit into one another, as they do in the halved and beveled splices, the splice is known as a "scarf" splice, and the operation of cutting and joining the parts is called "scarfing." Scarf splices are used, as we have already seen, both alone and in combination with fish plates. The fished splice is always the stronger, but the splice where scarfing alone is resorted to has the neatest appearance.

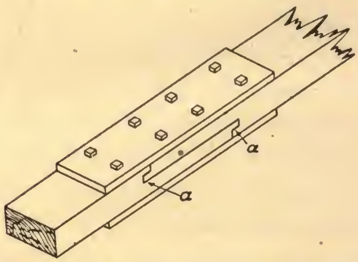


Fig. 44. Halved Splice with Fish Plates.

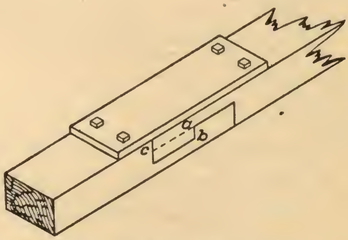


Fig. 45. Splice for Tension.

Splices for Tension. There are several common forms of splices for resisting direct tension. These differ from each other mainly in the amount of labor involved in making them. The simplest of them is shown in Fig. 45, and it will be seen that it is only a slight modification of the halved splice used for resisting compression. It is evident that the pieces cannot pull apart in the direction of their length until the timber crushes along the face marked *a-b*, or shears along the dotted line *a-c*. By varying the dimensions of the splice it may be made suitable for any situation. The parts are held closely together by the light fishplates shown in the figure, which also incidentally add something to the strength of the splice.

Instead of cutting the ends of the beams square, as shown in Fig. 45, they frequently are cut on a bevel as shown in Fig. 46,

and a further modification may be introduced by inserting a small "key" of hard wood between the pieces for them to pull against. This key is usually made of oak and may be in two parts, as shown in Fig. 47, each part in the shape of a wedge, so that when they are driven into place a tight joint may be obtained. The two wedge-shaped pieces may be driven in from opposite sides, the hole being made a little smaller than the key. If the key is made

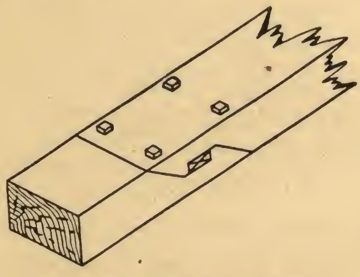


Fig. 46. Splice for Tension.

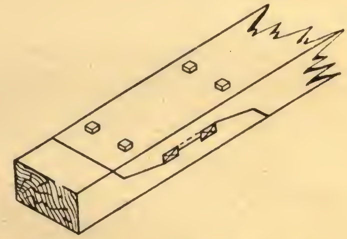


Fig. 47. Splice with Two Keys.

much too large for the hole, however, a so-called "initial" stress is brought into the timbers, which uses up some of their strength even before any load is applied. This should be avoided.

If it is desired, two or more keys may be employed in a splice, the only limiting condition being that they must be placed far enough apart so that the wood will not shear out along the dotted line shown in Fig. 48. Another feature of the splice here shown

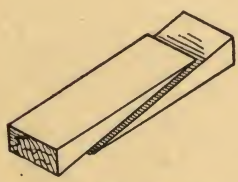


Fig. 48. Keys.

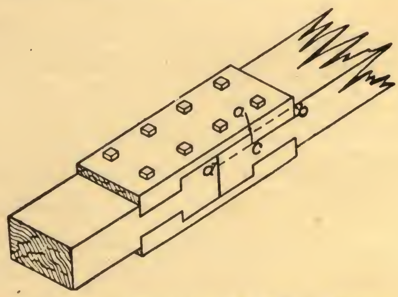


Fig. 49. Tension Splice with Fish Plates.

is the way in which the pieces are cut with two bevels on the end instead of one. One bevel starts at the edge of the key and is very gradual, the other starts at the extreme end of the piece and

is rather steep and sharp. These bevels can be used only in joints which resist tension alone. If such a splice were subjected to compression, the beveled ends would slide on each other and push by each other very easily, except as they are prevented from so doing by the fish plates, if these are used.

Tension Splice with Fish Plates. The splices for tension which have so far been described have all been scarf joints, but there is a fished splice which is very commonly used for tension. This splice is shown in Fig. 49. The fish plates, in this case of wood, are cut into the two pieces to be spliced, so as to hold them firmly together. The pieces cannot be pulled apart until one of the plates shears off along the dotted line *a-b*. The distance *c-d* must also be made large enough so that the piece will not shear. This splice is very often used for the lower chords of wooden trusses, and it is really one of the best that can be used for resisting direct tension.

(43)

Splices for Bending. It sometimes happens that a piece which is subjected to a bending stress must be spliced, and in this case the splice must be formed to suit the existing conditions. It is well known that in a timber which is resisting a bending stress the upper part of the piece is in compression, and the tendency is for the fibers to crush, while the lower part of the piece is in tension, and the tendency is for the fibers to pull apart. To provide for this, a form of splice must be selected which combines the features of the tension and compression splices. Fig. 50 shows such a splice. The parts are scarfed together as in the case of the other splices described, but in this case the end of the top piece is cut off square to offer the greatest possible resistance to crushing, while the underneath piece is beveled on the end, as there is no tendency for the timbers to crush. These cuts are shown in the figure.

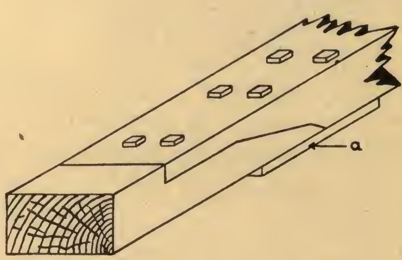


Fig. 50. Splice for Bending.

We have already seen that in the lower part of the splice

there is a tendency for the parts to be pulled away from each other. In order to prevent this, a fish plate *a* is used, which must be heavy enough to take care of all the tension, since it is evident that the wood cannot take any of this. The plate must be securely bolted to both parts of the splice. There is no need of a fish plate on the top of the pieces because there is no tendency for the pieces to pull apart on top, and the bolts shown in the figure are sufficient to prevent them from being displaced.

In any case where it is not desirable to scarf the pieces in a splice subjected to bending, the form of butt joint shown in Fig. 51 may be used. The plates (either of wood or iron) are in this case bolted to the sides of the pieces. If wood is used, of course the plates must be made very much heavier than if iron is used. In either case they must be large enough to take care of all the bending stress, and a sufficient number of bolts must be used to fasten them securely to both parts of the splice.

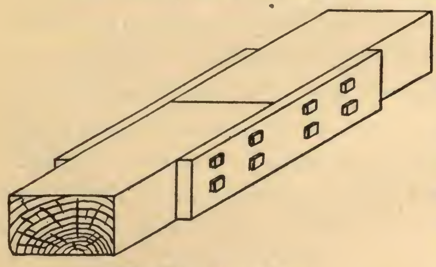


Fig. 51. Butt Joint.

THE WALL.

Let us next consider the framing of the walls of the building. In this work there are two distinct methods known respectively as "braced framing" and "balloon framing," of which the first is the older and stronger method, while the second is a modern development and claims to be more philosophical, as well as more economical, than the other. Balloon framing has come into use only since 1850, and is still regarded with disfavor by many architects, especially in the eastern states. Figs. 52 and 53 show the framing of one end of a small building by each of these methods, the braced framing in Fig. 52, and the balloon framing in Fig. 53.

Braced Frame. In a full-braced frame all the pieces should be fastened together with mortise-and-tenon joints, but this is much modified in common practice, a so-called "combination" frame being used, in which some pieces are mortised together and

others are fastened by means of spikes only. A framework is constructed consisting in each wall of the two "corner posts" A A (Fig. 52), the "sill" B, and the "plate" C, together with a horizontal "girt" D at each story, to support the floors, and a diagonal "brace" E at each corner, which, by keeping the corner square, prevents the frame from being distorted.

Balloon Frame. In a balloon frame there are no braces or girts; and the intermediate studs F F F (Fig. 53) are carried straight up from the sill H to the plate K, with a light horizontal piece J, called a "ribbon" or "ledger board," set into them at each floor level to support the floors. This frame depends mainly

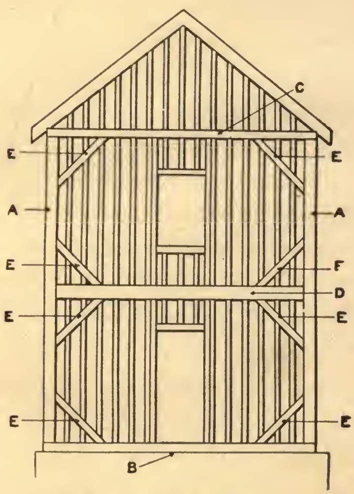


Fig. 52. Braced Frame.

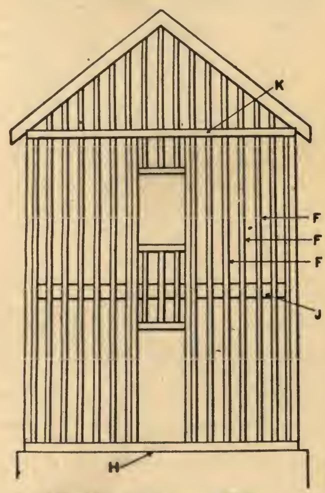


Fig. 53. Balloon Frame.

upon the boarding for its stiffness, but sometimes light diagonal braces are set into the studs at each corner to prevent distortion. The methods by which all these pieces are framed together will be explained in detail under the proper headings.

The Sill. The sill is the first part of the frame to be set in place. It rests directly on the underpinning and extends all around the building, being jointed at the corners and spliced where necessary; and since it is subject to much cutting and may be called upon to span quite considerable openings (for cellar windows, etc.) in the underpinning, it must be of good size. Usually it is made of six by six square timber, but in good work

it should be six by eight, and nothing lighter than six by six should be used except for piazza sills. For piazza sills a four by six timber is used. The material is generally spruce, although sometimes it is Norway pine or native pine (depending upon the locality).

The sill should be placed on the wall far enough back from the outside face to allow for the water table, which is a part of the outside finish; and one inch should be regarded as the minimum distance between the outside face of the sill and the outside face of the underpinning (see Fig. 54). A bed of mortar A, preferably of cement mortar, should be prepared on the top of the underpinning, in which the sill C should rest; and the under side of the sill should be painted with one or two coats of linseed oil to prevent it from absorbing moisture from the masonry. In many cases, at intervals of eight or ten feet, long bolts B are set into the masonry. These bolts extend up through holes bored in the sill to receive them, and are fastened at the top by a washer and a nut screwed down tight. They fasten the sill, and consequently the whole frame, securely to the underpinning, and should always be provided in the case of light frames in exposed positions.

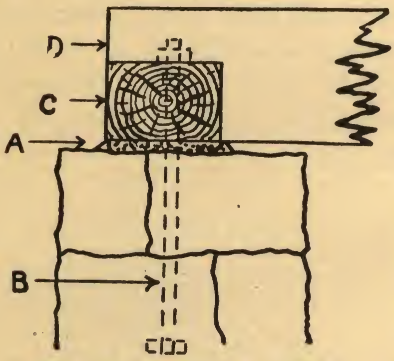


Fig. 54. Sill Placed on Wall.

The beams or "joists" D, which form the framework of the first floor, are supported at one or both ends by the sill and may be fastened to it in any one of several different ways. The ideal method is to hang the joist in a patent hanger fastened to the sill as shown in Fig. 55, where A is the sill, B the joist, and C the hanger. In this case neither the sill nor the joist need be

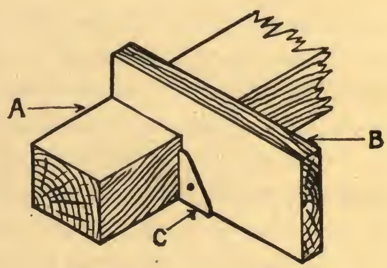


Fig. 55. Patent Hanger.

weakened by cutting, but this is too expensive a method for ordinary work, although the saving in labor largely offsets the cost of the hanger. The usual method is to cut a mortise in the sill to receive a tenon cut in the end of the joist (as shown at A in Fig. 56). These mortises are cut in the inside upper corner of the sill, are about four inches deep and cut two inches into the width of the sill, and are fixed in position by the spacing of the joists.

Mortises are also cut in the sill to receive tenons cut in the lower ends of the studs (as shown at B in Fig. 57). They are cut the full thickness of the studding, about one and one-half inches in the width of the sill and about two inches deep. The position of these is fixed by the spacing of the studding, and by the condition that the outer face of the studding must be flush with the outer face of the sill in order to leave a plain surface for the boarding.

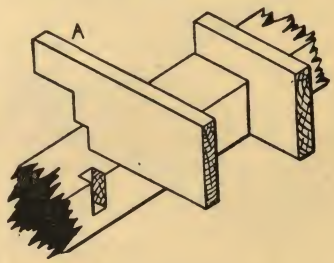


Fig. 56. Mortise in Sill.

The sills are usually halved and pinned together at the corners, as shown in Fig. 58; but sometimes they are fastened together by means of a tenon A cut in one sill, which fits into a mortise cut

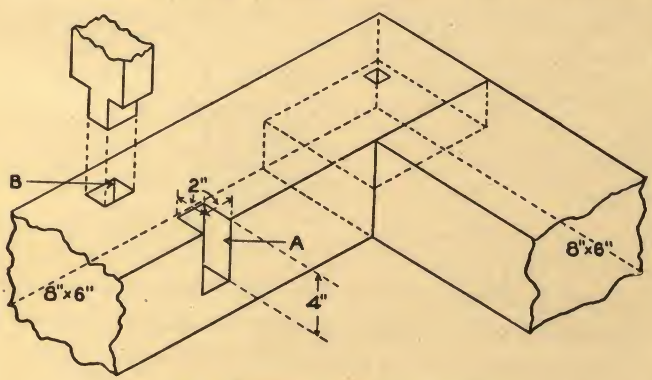


Fig. 57. Mortise in Sill for Studding.

in the other, as shown in Fig. 59. This may be stronger than the other method, but the advantage gained is not sufficient to compensate for the extra labor involved. Sills under twenty feet in

length should be in one piece, but in some cases splicing may be necessary. A scarf joint should always be used, the splice should be made strong, and the pieces should be well fitted together.

In some parts of the country it is customary to "build up" the sill from a number of planks two or three inches thick, which are spiked securely together. A six-by-six-inch sill may be made in this way from three planks, two inches thick and six inches wide, as shown in Fig. 60. Planks of any length may be used, and may be so arranged as to break joints with each other so that the sill may be made continuous, without splicing. It is often easier and cheaper to build up a sill in this way than it is to use a large, solid timber, and if the parts are well spiked together, such a sill is fully as good as the other. When a sill of this kind is used, however, it should always be placed on the wall in such a way that the planks of which it is made up will set up on edge and not lie flat.

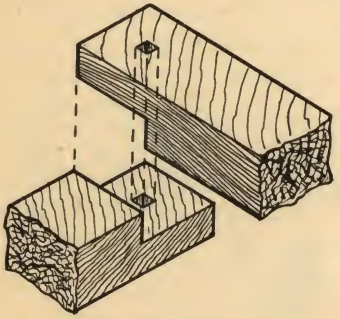


Fig. 58. Joint of Sills at Corner.

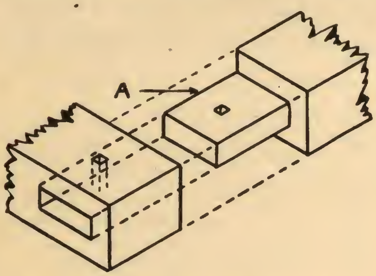


Fig. 59. Joint of Sills at Corner.

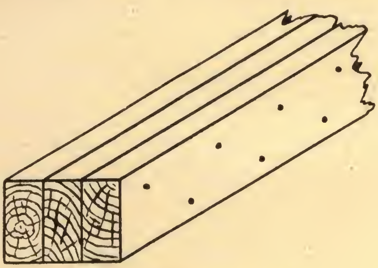


Fig. 60. "Built-up" Sill.

The Corner Posts. After the sill is in place, the first floor is usually framed and roughly covered at once, to furnish a surface on which to work, and a sheltered place in the cellar for the storage of tools and materials, after which the framing of the wall is continued. The corner posts are first set up, then the girts and the plate are framed in between them, with the braces at the corners to keep everything in place; and lastly the whole is filled in with studding. The corner posts are pieces four by eight, or

sometimes two pieces four by four placed close together. Corner posts must be long enough to reach from the sill to the plate. The post is really a part of only one of the two walls which meet at the corner, and in the other wall a "furring stud" of two-by-four stuff is placed close up against the post so as to form a solid

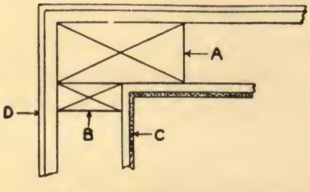


Fig. 61. Corner Post with One Furring Stud.

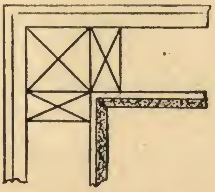


Fig. 62. Corner Post with Two Furring Studs.

corner, and give a firm nailing for the lathing in both walls. This arrangement is shown in plan in Fig. 61. A is the corner post, B the furring stud, C the plastering, and D the boarding and shingling on the outside. Sometimes a four-by-four piece is used for the corner post and a two-by-four furring stud is set close against it in each wall to form the solid corner, as shown in plan in Fig. 62; but a four-by-four-stick is hardly large enough for the long corner post, and the best practice is to use a four-by-eight, although in very light framing a four-by-six might be used. A tenon is cut in the foot of the corner post to fit a mortise cut in the sill, and mortises *c c*, Fig. 63, are cut in the post at the proper level to receive the tenons cut in the girts. Holes must also be bored to receive the pins *d d* which fasten these members to the post.

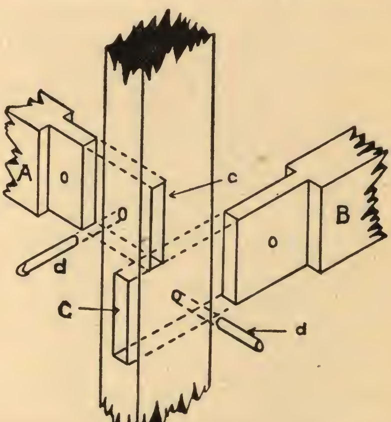


Fig. 63. Mortises in Corner Post.

The braces are often only nailed in place, but it is much better to cut mortises in the posts for these also, as shown at A in Fig. 64. The plate is usually fastened to the posts by means of spikes only, but it may be mortised to receive a tenon cut in the top of the post.

In the case of a balloon frame no mortises need be cut in the posts for the girts or braces, as they are omitted in this frame; but the post must be notched instead, as shown in Fig. 65, to receive the ledger board or ribbon and the light braces which are sometimes used.

The Girts. The girts are always made of the same width as the posts, being flush with the face of the post both outside and inside, and the depth is usually eight inches, although sometimes a six-inch timber may be used. The size is, therefore, usually four by eight. A tenon at each end fits into the mortise cut in the

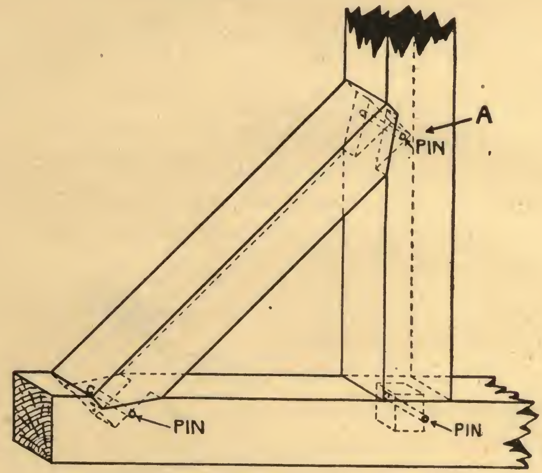


Fig. 64. Brace for Post and Sill.

post, and the whole is secured by means of a pin *d d* as shown in Fig. 63. The pin should always be of hard wood and about seven-eighths inch in diameter. It is evident that if the girts in two adjacent walls were framed into the corner post at the same level, the tenons on the two girts would conflict with each other. (See Fig. 63.) For this reason the girts A which run parallel with the floor joists are raised above the girts B on which these joints rest, and are called "raised girts" to distinguish them from the others which are called "dropped girts." The floor joists are carried by the dropped girts, and the raised girts are so placed that they are just flush on top with the joists which are parallel to them.

The Ledger Board. The heavy girts are used only in the

braced frame. In the balloon frame, light pieces called "ledger boards" or "ribbons" are substituted for them. These are usually made about one inch thick and six or seven inches deep, and are notched into the posts and intermediate studs instead of being

Fig. 65.

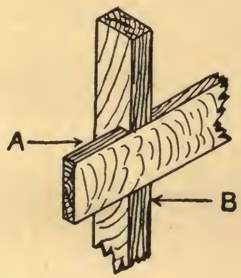


Fig. 66.

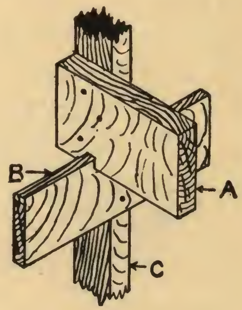


Fig. 67.

Notched Studs for Ledger Boards.

framed into them as in the braced frame. This notching is shown in Fig. 66 in which A is the ledger board and B the stud. The ledger boards themselves are not cut at all, but the floor joists which they carry are notched over them, as shown in Fig. 67, and spiked to them and to the studding. In Fig. 67 A is the joist, B the ledger board, and C the stud. Even in the braced frame a ledger board is usually employed to support the joists of the attic floor, which carry little or no weight. The disadvantage of the ledger board is that as a tie between the corner posts it is less effective than the girt, and consequently a wall in which it has been substituted for the girt is not as stiff as one in which the girt is used.

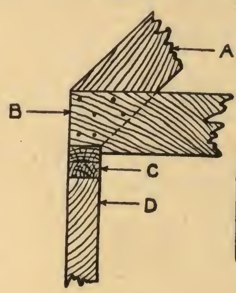


Fig. 68.

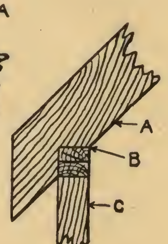


Fig. 69.

Construction at Plate.

The Plate. The plate serves two purposes: first, to tie the studding together at the top and form a finish for the wall; and second, to furnish a support for the lower ends of the rafters. (See Fig. 68). It is thus a connecting link between the wall and the roof, just as the sill and the girts are connecting links between

the floors and the wall. Sometimes the plate is also made to support the attic floor joists, as shown in Fig. 68, in which A is a rafter, B the joist spiked to the rafter, C the plate built up from two two-by-four pieces, and D the wall stud. It acts in this case like a girt, but this arrangement is not very common, the attic floor joists usually being supported on a ledger board as shown in Fig. 67. The plate is merely spiked to the corner posts and to the top of the studding; but at the corner where the plates in two adjacent walls come together, they should be connected by a framed joint, usually halved together in the same way as the sill. In the braced frame, a fairly heavy piece, usually a four by six, is used, although a four by four is probably sufficiently strong. In a balloon frame the usual practice is to use two two-by-four pieces placed one on top of the other and breaking joints, as shown at A in Fig. 70, in order to form a continuous piece. The corner joint is then formed, as shown at B in Fig. 70. No cutting is done on the plate except at the corners, the rafters and the attic floor joists being cut over it, as shown in Figs. 68 and 69.

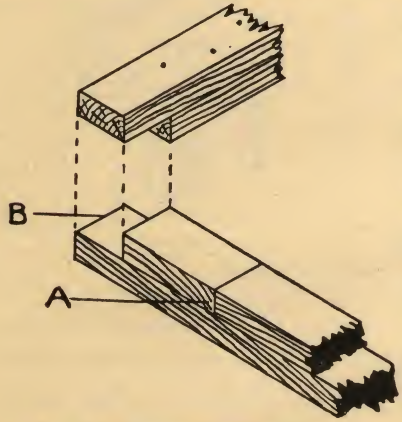


Fig. 70. Construction at Corner, "Breaking Joints."

Braces. Braces are used as permanent parts of the structure only in braced frames, and serve to stiffen the wall, to keep the corners square and true, and to prevent the frame from being distorted by lateral forces, such as wind. In a full-braced frame, a brace is placed wherever a sill, girt, or plate makes an angle with a corner post, as shown at E in Fig. 52. Braces are placed so as to make an angle of forty-five degrees with the post, and should be long enough to frame into the corner post at a height of from one-third to one-half the height of the story. This construction is often modified in practice, and the braces are placed as shown at A in Fig. 71. Such a frame is not quite so stiff and strong as the regular braced frame, but it is sufficiently strong in most cases.

The braces are made the same width as the posts and girts, usually four inches, to be flush with these pieces both outside and inside, and are made of three-by-four or four-by-four stuff. They are framed into the posts and girders or sills, by means of a tenon cut in the end of the brace, and a mortise cut in the post or girt, and are secured by a hard-wood pin. The pin should be three-quarters or seven-eighths inch in diameter. The connection is shown in Fig. 64.

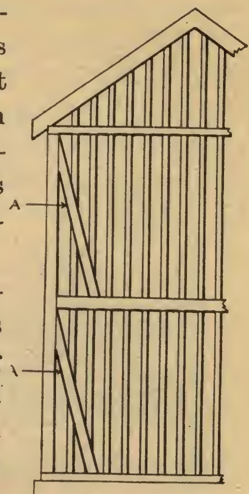


Fig. 71. Braced Frame.

In a balloon frame, there are no permanent braces, but light strips are nailed across the corners while the framework is being erected, and before the boarding has been put on, to keep the frame in place. As soon as the outside boarding is in place these are removed. This practice is also modified, and sometimes light braces are used as permanent parts of even a balloon frame. They are not framed into the other members, however, but are merely notched into them and spiked as shown in Fig. 72. A is the brace, B the sill, C the corner post, and D D are studs. In such a case every stud must be notched to receive the brace, which is really the same as the temporary brace mentioned above, except that it is notched into the studs instead of being merely nailed to them, and is not removed when the boarding is put on. These braces are usually made of one-by-three-inch stuff.

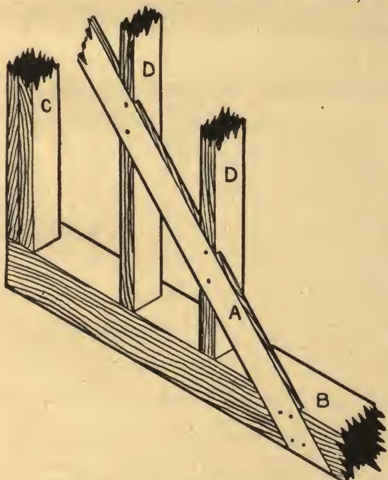


Fig. 72. Temporary Brace.

Studding. When the sill, posts, girts, plates, and braces are in place, the only step that remains to complete the rough framing of the wall is the filling in of this framework with studding. The studding is of two kinds, the heavy pieces which form the frames

for the door and window openings, and the stops for the partitions; and the lighter pieces which are merely "filling-in" studs, and which are known by that name, or as "intermediate" studding.

The frames for the door and window openings are usually made in a braced frame, from four-by-four-inch pieces. A vertical stud A A, Fig. 73, is placed on each side of the opening, the proper distance being left between them, and horizontal pieces B B are framed into them at the proper level to form the top and the bottom of the opening. In all good work a small truss is formed above each opening by setting up two pieces of studding C C over the opening, in the form of a triangle. This is to receive any weight which comes from the studding directly above the opening, and carry it to either side of the opening where it is received by the studding and in this way carried down to the sill. Such a truss is shown in Fig. 73. The pieces used are three by four or four by four, and may be either framed into the other members or merely spiked. There should be a space D of at least one inch between the piece B forming the top of the window frame and the piece E forming the bottom of the truss, so that if the truss sags at all it will not affect the window frame. This is a point that is not generally recognized. The piece B is usually made to serve both as the top of the window and the bottom of the truss.

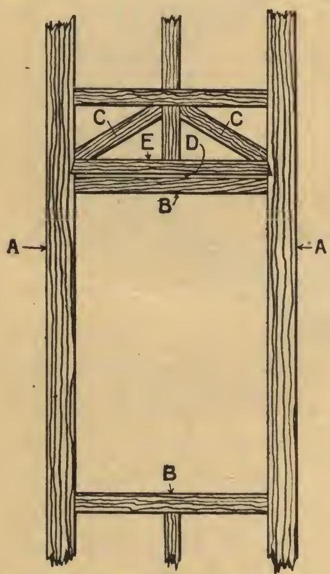


Fig. 73. Truss over Window. in a braced frame.

Fig. 74 shows the framing for the top of a window opening in a balloon-framed building, where the ledger-board is partly supported by the studs directly over the opening. Since the floor joists rest on the ledger-board, there may be considerable weight carried onto these studs; and to prevent the bottom of the truss from sagging under this weight, a rod should be inserted as shown.

In the balloon frame, the door and window studs are almost always made of two two-by-four pieces placed close together, and in this case the connection of the pieces forming the top and

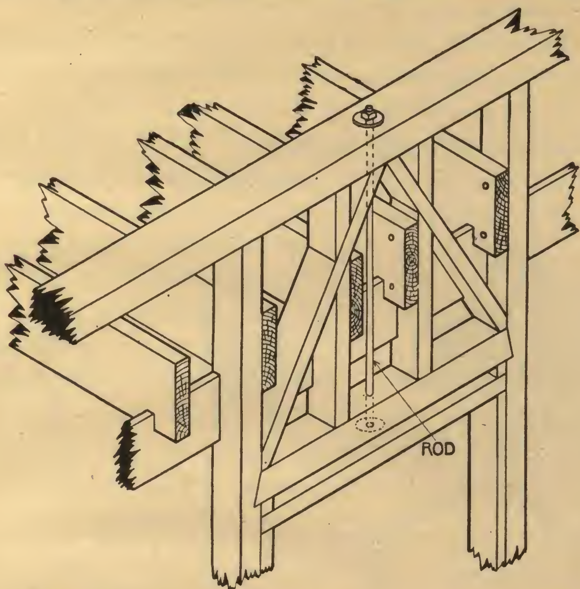


Fig. 74. Truss over Window. Balloon Frame.

bottom of the frame with those forming the sides is made as shown at A in Fig. 75. It should be noticed that in a balloon frame all studding is carried clear up from the sill to the plate, so that if there is an opening in the wall of the first story, and no corresponding openings in those of the second or third story, the door and window studding must still be carried double, clear up to the plate, and material is thus wasted. In designing for balloon frames, therefore, it is well to take care that the window openings in the second story come directly above those in the first story wherever this is possible. The same difficulty does not occur in the case of a braced frame, because in such a frame the studding in each story is independent of that in the story above or below it, and the openings may be arranged independently in the different stories.

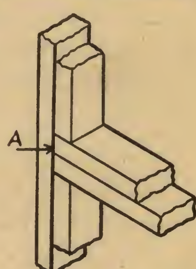


Fig. 75.

Nailing Surfaces. Wherever a partition meets an outside wall, a stud wide enough to extend beyond the partition on both sides and afford a solid nailing for the lathing must be inserted. A nailing surface must be provided for the lathing on both the outside wall and the partition, and the first stud in the partition wall is therefore set close up against the wall stud, forming a solid corner. This arrangement is shown in plan in Fig. 76. The large wall stud A is usually made of a four-by-eight piece set flatwise in the wall so that if the partition is, say, four inches wide, there is a clear nailing surface of two inches on each side of the partition. A four-by-six piece could also be used here, leaving a clear nailing surface of one inch on each side of the partition.

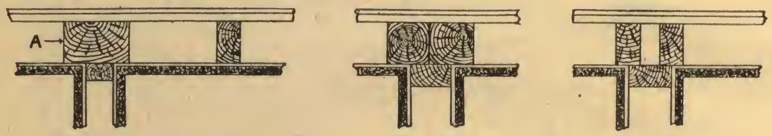


Fig. 76. Fig. 77. Fig. 78.

Arrangement of Studding for Nailing Surfaces.

Sometimes the same thing is accomplished by using two four-by-four pieces placed close together as shown in plan in Fig. 77, instead of one four-by-eight piece. Sometimes two pieces, two-by-four or three-by-four, are used, placed far enough apart so that they afford a space for nailing on each side of the partition, as shown in plan in Fig. 78. Whenever this is done, small blocks A, Fig. 79, should be cut in between the two studs at intervals of two to three feet throughout their height, to give them added stiffness and make them act together.

The end in view in every case is to obtain a solid corner on each side of the partition where it joins the wall, and any construction which accomplishes this is good. In the best work, however, the four-by-eight solid piece is used, and this construction can always be depended upon. It makes no difference what the angle between the wall and the partition may be, but usually this angle is a right angle.

Intermediate Studding. The pieces which make up the largest part of the wall frame are the "filling-in," or "intermediate" studs. These, as the name implies, are used merely to fill up the frame made by the other heavier pieces, and afford a nail-

ing surface for the boarding, which covers the frame on the outside, and the lathing, which covers it on the inside. The filling-in studs are usually placed sixteen inches apart, measured from the center of one stud to the center of the next. In especially good work they are sometimes placed only twelve inches apart on centers, but this is unusual. In no case should they be placed more than sixteen inches apart, even in the lightest work. The studs are made the full width of the wall, usually four inches, but sometimes in large buildings (such as churches) five or even six inches. They are almost always two inches thick, two by four being the ordinary dimensions for studding, and the lengths are cut to fit the rest of the frame.

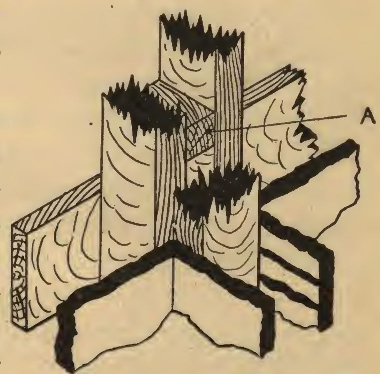


Fig. 79. Wall Studding.

In the braced frame, there must necessarily be a great deal of cutting of the intermediate studding, because all the large pieces are made the full width of the wall, and the intermediate studding must be cut to fit between them. In the balloon frame, however, the intermediate studding in all cases extends clear up from the sill to the plate, and no cutting is necessary except the notching to receive the other parts of the frame. (See Fig. 53.)

In a balloon frame it often happens that the studs are not long enough to reach from the sill to the plate and they must be pieced out with short pieces which are spliced onto the long stud. This splicing is called "fishing," and it is accomplished by nailing a short, thin strip of wood A A on each side of the stud as shown in Fig. 40 in order to join the two pieces firmly together. The strips should be well nailed to each piece.

All door and window studs should have a tenon cut at the foot of the piece to fit a mortise cut in the sill. Intermediate studs are merely spiked to the sill without being framed into it. The tenons are cut in two different ways, as shown in Figs. 80 and 81. They are always made the full thickness of the piece, and by the first method they are placed in the middle of the

piece, as shown. The width of the tenon is about one and one-half inches, leaving an inch and a-half on the outside and one inch on the inside of the stud. Another way is to make the tenon on the inside of the stud, as shown in Fig. 81, the tenon being an inch and a-half wide as before. There is no choice between these two methods, both being good.

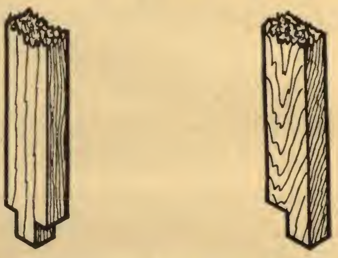


Fig. 80. Tenons for Studs. Fig. 81.

Partitions. The studding used in partition walls is usually of two-by-four stuff, although two-by-three studding may sometimes be used to advantage if the partition does not support any floor joists.

The partition walls are made four inches wide, the same as in the outer walls, except in the case of so-called "furring" partitions. These are built around chimney breasts and serve to conceal the brickwork and furnish a surface for plastering. They are formed by placing the studding flatwise, in order to make a thin wall; and as it is usually specified that no woodwork shall come within one inch of any chimney, a one-inch space is left between the brickwork and the furring wall. It is possible to apply the plaster directly to the brickwork, and this is sometimes done, but there is always danger that cracks will appear in the plastering at the corner A, Fig. 82, between the chimney breast and the outside wall. This cracking is due to the unequal settlement of the brickwork and the woodwork, since the plastering goes with the wall to which it is applied. The method of constructing the furring wall is shown in plan in Fig. 83. A A are the furring studs, B is the plastering, and C C the studding in the outside wall. The arrangement without the furring wall is shown in plan in Fig. 82. If there are any openings in the furring wall such as fireplaces, or "thimbles" for stove pipes, it is necessary to frame around them in the same way as was explained for door and window openings in the outside walls.

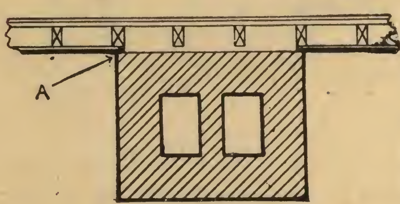


Fig. 82. Plastering around Chimney.

See Fig. 84. A A are furring studs, B B are pieces forming the top and bottom of the opening.

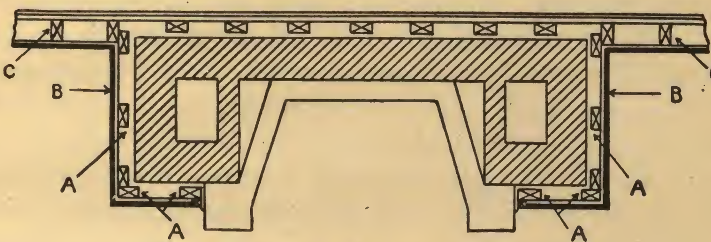


Fig. 83. Furring Wall around Chimney.

Masonry Walls. If the outside walls of the building are of brick or stone, a wooden "furring" wall is usually built just inside of the outer wall; this furnishes a surface for plastering and for nailing the inside finish. The studding for these walls is two-by-four or two-by-three set close up against the masonry wall

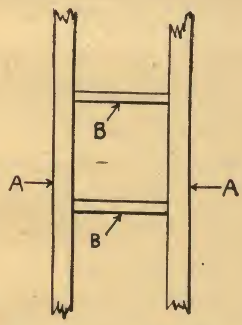


Fig. 84. Opening for Thimble.

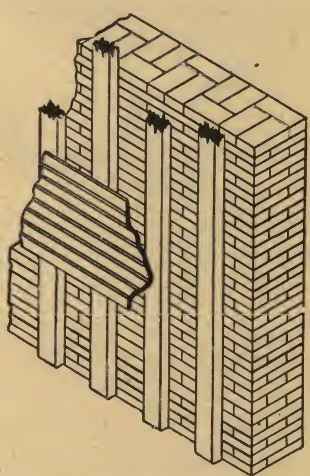


Fig. 85. Furring for Brick Wall.

and preferably spiked to it (see Fig. 85). Spikes are usually driven directly into the mortar between the bricks or stones of the wall, but sometimes wooden blocks or wedges are inserted in the masonry wall to afford a nailing.

Wherever a wooden partition wall meets a masonry exterior wall at an angle, the last stud of the partition wall should be

securely spiked to the masonry wall, to prevent cracks in the plastering.

Cap and Sole. All partition walls are finished at the top and bottom by horizontal pieces, called respectively the cap and the sole. The sole rests directly on the rough flooring whenever there is no partition under the one which is being built; but if there is a partition in the story below, the cap of the lower partition is used as the sole for the one above. The sole is made wider than the studding forming the partition wall, so that it projects somewhat on each side and gives a nailing for the plasterer's

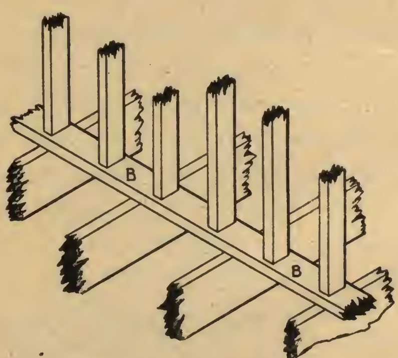


Fig. 86. Sole Piece.

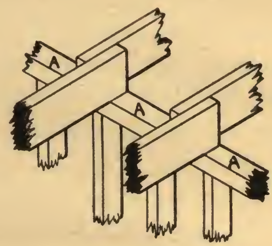


Fig. 87. Partition Cap.

grounds and for the inside finish. It is usually made about two inches thick and five and a-half inches wide, when the partition is composed of four-inch studding, and this leaves a nailing surface of three-quarters of an inch on each side. The sole is shown at B in Fig. 86. The cap is usually made the same width as the studding, and two inches thick, so that a two-by-four piece may be used in most cases; but if the partition is called upon to support the floor beams of the floor above, the cap may have to be made three or even four inches thick, and some architects favor the use of hardwood such as Georgia pine for the partition caps. The cap is shown at A, Fig. 87.

Bridging. In order to stiffen the partitions, short pieces of studding are cut in between the regular studding in such a way as to connect each piece with the pieces on each side of it. Thus, if one piece of studding is for any reason excessively loaded, it will

not have to carry the whole load alone but will be assisted by the other pieces. This operation is called "bridging," and there are two kinds, which may be called "horizontal bridging" and "diagonal bridging." The horizontal bridging consists of pieces set in horizontally between the vertical studding to form a continuous horizontal line across the wall, every other piece, however, being a little above or below the next piece as shown in Fig. 88. The pieces are two inches thick and the full width of the studding; and in addition to strengthening the wall, they prevent fire or vermin from passing through, and also may be utilized as a nailing surface for any inside finish such as wainscoting or chair rails.

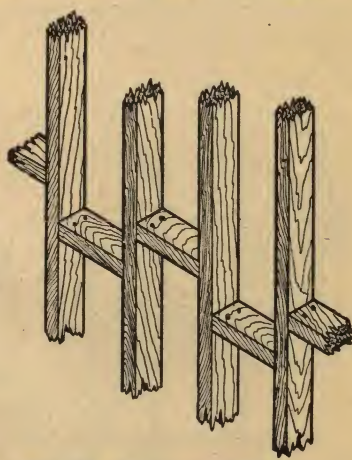


Fig. 88. Horizontal Bridging.

The second method, which we have called diagonal bridging, is more effective in preventing the partition from sagging than is the straight bridging, but both methods may be used with equal propriety. In the diagonal bridging the short pieces are set in diagonally as is shown in Fig. 89, instead of horizontally, between the vertical studding. This method is certainly more scientific than the other, since a continuous truss is formed across the wall.

All partitions should be bridged by one of these methods, at least once in the height of each story, and the bridging pieces should be securely nailed to the vertical studding at both ends. It is customary to specify two tenpenny nails in each end of each piece. Bridging should be placed in the exterior walls as well as in the partition walls; and as a further precaution against fire, it is good practice to lay three or four courses of brickwork, in mortar, on top of the bridging in all walls, to prevent the fire from gaining headway in the wall before burning through and being discovered. This construction is shown in Fig. 90.

Special Partitions. A partition in which there is a sliding door must be made double to provide a space into which the door

may slide when it is open. This is done by building two walls far enough apart to allow the door to slide between them, the studding being of two-by-four or two-by-three stuff, and placed either flatwise or edgewise in the wall. If the studding is placed flatwise in the wall, a thinner wall is possible, but the construction is not so good as in the case where the studs are placed edgewise. If the partition is to support a floor, one wall must be made at least four inches thick to support it, and the studs in the other wall

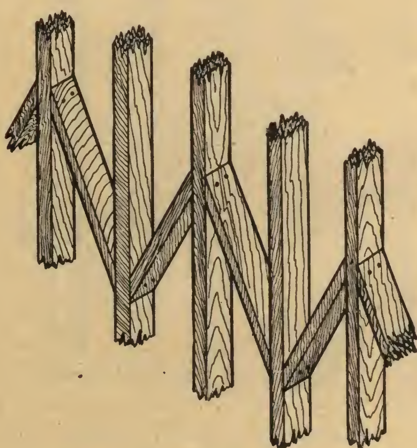


Fig. 89. Diagonal Bridging.

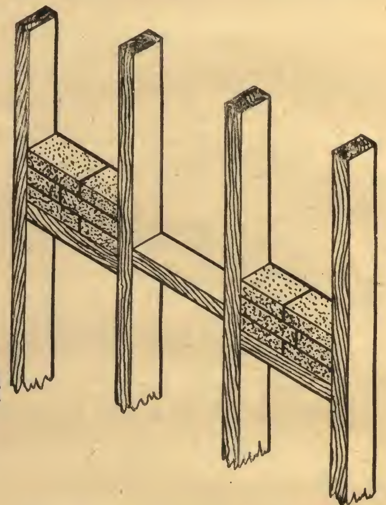


Fig. 90. Brick Work on Bridging.

may then be placed flatwise if desired, and the floor supported entirely on the thick wall. The general arrangement is shown in plan in Fig. 91. It is better to use two-by-three studding set edgewise in each wall so as to make two three-inch walls with space enough between to allow the door to slide freely after the pocket has been lined with sheathing.

A piece of studding A, Fig. 92, should be cut in horizontally between each pair of studs B, eight or ten inches above the top of the door, in order to keep the pocket true and square. The pocket should be lined on the inside with matched sheathing C.

It is well known that ordinary partitions are very good conductors of sound; and in certain cases, as in tenement houses, this is objectionable, so that special construction is required. If two

walls are built entirely separate from each other, and not touching at any place, the transmission of sound is much retarded; and if heavy felt paper or other material is put in between the walls, the partition is made still more nearly sound-proof. In order to decrease the thickness of such a wall as much as possible, the "staggered" partition is used, in which there are two sets of studding, one for each side of the wall, but arranged alternately instead of in pairs as in the double partition. The arrangement is shown in plan in Fig. 93. The two walls are entirely separate from each other and the felt paper may be worked in between the studs as shown, or the whole space may be packed full of some sound-proof and fireproof material such as mineral wool. There is a so-called "quilting paper" or "sheathing quilt" manufactured from seaweed, which is much used for this purpose. The inside edges of the two

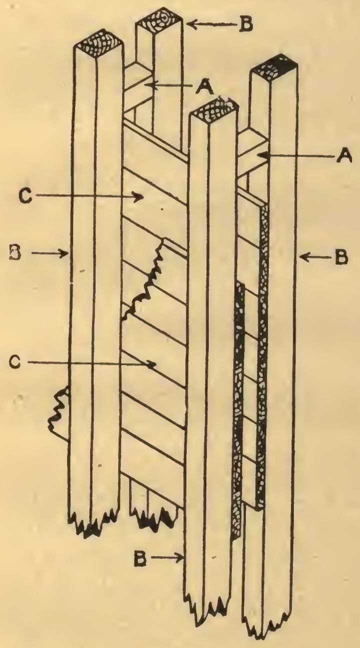


Fig. 92. Double Partition.

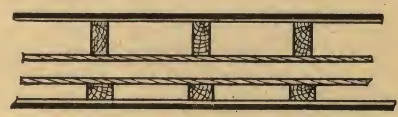


Fig. 91. Double Partition for Sliding Door.

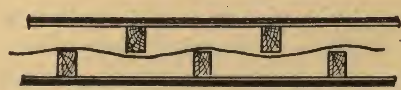


Fig. 93. Sound-proof Partition.

sets of studs are usually placed on a line, making the whole wall eight inches thick where four-inch studding is used, and the studs may be placed about sixteen inches on centers in each wall. Each set of studding should be bridged separately.

Another case where a double wall may be necessary, is where pipes from heaters or from plumbing fixtures are to be carried in the wall. In case of hot pipes, care must be taken to have the space large enough so that the woodwork will not come dangerously near the pipes.

An important matter in connection with the framing of the partitions is the way in which they are supported; but this involves knowledge of the framing of the floor, and therefore it will be left for the present. It will be taken up after we have considered the floor framing.

Shrinkage and Settlement. An important point which must be considered in connection with the framing of the walls and partitions, is the settlement due to the shrinkage of timber as it seasons after being put in place. Timber always shrinks considerably *across* the grain, but very little in the direction of the grain; so it is the horizontal members such as the sills, girts, and joists which cause trouble, and not the vertical members such as the posts and studding. Every inch of horizontal timber between the foundation wall or interior pier and the plate is sure to contract a certain amount, and as the walls and partitions are supported on these horizontal members, they too must settle somewhat. If the exterior and interior walls settle by exactly the same amount, no harm will be done, since the floors and ceilings will remain level and true as at first; but if they settle unequally, all the levels in the building will be disturbed, and the result will be cracking of the plastering, binding of doors and windows, and a general distortion of the whole frame. This must be avoided if possible.

It is evident that one way to prevent unequal settlement, so far at least as it is due to the shrinkage of the timber, is to make the amount of horizontal timber in the exterior and interior walls, equal. Thus, starting at the bottom, we have from the masonry of the foundation wall to the top of the first-floor joists in the outside walls, ten inches, or the depth of the joists themselves, since these rest directly on the top of the wall. In the interior we have, if the joints are framed flush into a girder of equal depth, the same amount, so that here the settlement will be equal. But the studding in the exterior wall rests, not on the top of the joists, but on the top of the six-inch sill, while the interior studding rests on top of the ten-inch girder. Here is an inequality of four inches which must be equalized before the second floor level is reached. If the outer ends of the second-floor joists rest on the top of an eight-inch girt, and the inner ends on a four-inch par-

tition cap, this equalizes the horizontal timber inside and outside, and the second floor is safe against settlement. The same process of equalization may be continued to the top of the building, and if this is done it will go far toward preventing the evils resulting from settlement and shrinkage.

With a balloon frame this cannot be done, because there are no girts in the outside walls, but only ledger-boards which are so fastened that they cannot shrink, while in the interior walls we have still the partition caps. All that can be done in this case is to make the depths of the sills and interior girders as nearly equal as possible, and to make the partition caps as shallow as will be consistent with safety.

THE FLOORS.

After the wall, the next important part of the house frame to be considered is the floors, which are usually framed while the wall is being put up and before it is finished. They must be made not only strong enough to carry any load which may come upon them, but also stiff enough so that they will not vibrate when a person walks across the floor, as is the case in some cheaply-built houses. The floors are formed of girders and beams, or "joists," the girders being large, heavy timbers which support the lighter joists when it is impossible to allow these to span the whole distance between the outside walls.

Girders are generally needed only in the first floor, since in all the other floors the inner ends of the joists may be supported by the partitions in the floor below. They are usually of wood, though it may sometimes be found economical to use steel beams in large buildings. Wrought iron was once used, but steel is now cheaper and has taken the place of wrought iron. It is rarely, however, that this will be found expedient, and hard pine girders will answer very well in most cases. The connections used in the case of steel girders will be explained later. The girders may be of spruce or even of hemlock, but it is hard to get the hemlock in such large sizes as would be required for such girders, and spruce, too, is hardly strong enough for the purpose. Southern pine, therefore, is usually employed for girders in the best work.

The size of the girder depends on the span, or the distance between the supporting walls, and upon the loads which the floor is expected to carry. In general, the size of a beam or girder varies directly as the length of the span, so that if we have two spans, one of which is *twice* as great as the other, the girder for the longer span should be *twice* as strong as the girder for the smaller span. In ordinary houses, however, all the girders are made about eight by twelve inches in section, although sometimes an eight-by-eight timber would suffice, and sometimes perhaps a twelve-inch piece would be required.

Fig. 94.

It should be remembered in deciding upon the size of this piece, that any girder is increased in strength in direct proportion to the *width* of the timber (that is, a girder 12 inches wide is twice as strong as one 6 inches wide), but in direct proportion also to the *square of the depth* (that is, a girder 12 inches deep is four times as strong as one 6 inches deep). Hence the most economical girder is one which is deeper than it is wide, such as an eight-by-twelve stick; and the width may be decreased by any amount so long as it is wide enough to provide sufficient stiffness, and the depth is sufficient to enable the piece to carry the load placed upon it. If the piece is made too narrow in proportion to its depth, however, it is likely to fail by "buckling," that is, it would bend as shown in Fig. 94. The width should be at least equal to one-sixth of the depth.

There are at least three ways in which the joists may be supported by the girder. The best but most expensive method is to support the ends of the joists in patent hangers or stirrup irons which connect with the girder. This method is the same as was described for the sill, except that with the girder a double stirrup iron, such as that shown in Fig. 95, may be used. These stirrup-iron hangers are made of wrought iron, two and one-half or three inches wide, and about three-eighths of an inch thick, bent into the required shape. They usually fail by the crushing of the wood of the girders, especially when a single hanger, like that

shown in Fig. 96, is used. Fig. 97 shows a double stirrup-iron hanger in use. Patent hangers as shown in Fig. 98 are by far the best.

If hangers of any kind are used, there will be no cutting of the girder except at the ends where it frames into the sill, and even there a hanger may be used. The girder may be placed so that the joists will be flush with it on top, or so that it is flush

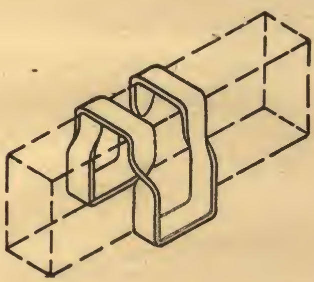


Fig. 95.

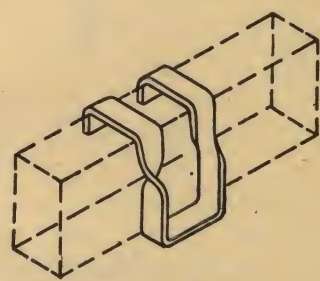


Fig. 96.

with the sill on top. If the joists are flush with the girder on top, and are framed into the sill in the ordinary way, as shown in Fig. 99, the girder cannot be flush on top with the sill; while, on the other hand, if the girder is flush with the sill on top, it cannot at the same time be flush with the joists on top. If joist hangers are used on the girder to support the joists, they will probably be

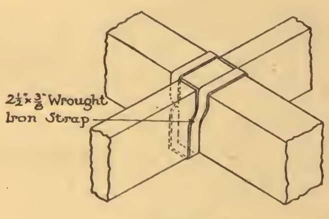


Fig. 97.

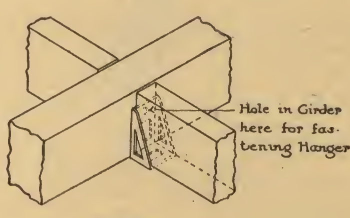


Fig. 98.

used on the sill as well, as explained in connection with the sill; and in this case the girder can be made flush with the sill on top and the joists hung from both girder and sill with hangers, thus bringing both ends of the joist at the same level, as shown in Fig. 100. If the girder is framed into the sill at all, it would almost

always be made flush with the sill on top, and the joists would be arranged so as to be level.

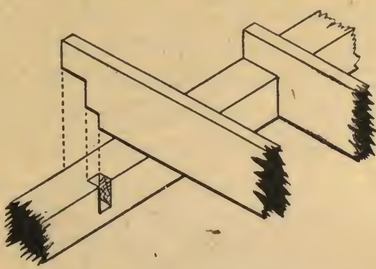


Fig. 99. Framing of Joist into Sill.

For framing the girder into the sill, a tenon-and-tusk joint, as shown in Fig. 101, would be used if the girder is to be flush with the sill on top. Since the girder would in most cases be deeper than the sill, the latter having a depth of only six inches, the wall would necessarily have to be cut away in order to make a place for the girder. This condition is clearly shown in Fig. 102. The girder itself should not be cut over the wall as shown in Fig. 103, because this greatly weakens the girder. If this method is used, the joists should be framed into

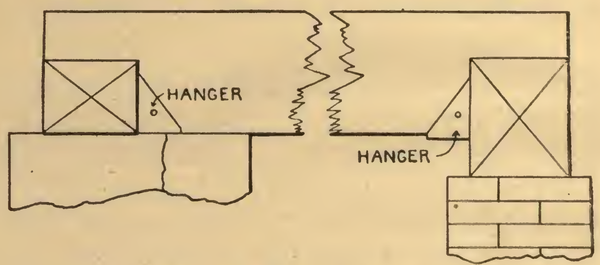


Fig. 100. Use of Hangers.

the girder in the same way as they are framed into the sill, a mortise being cut in the girder and a tenon on the joist. This is called "gaining" and is shown in Fig. 99. The top of the girder thus comes several inches below the top of the floor.

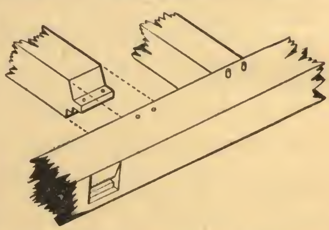


Fig. 101. Framing of Girder into Sill.

Another method is to make the top of the girder flush with the top of the joists. The joists are then framed into the girder with a tenon-and-tusk joint, as shown in Fig. 101, and the girder is "gained" into the sill as shown in Fig. 99.

Still another method in common use is simply to "size

down" the joists on the girder about one inch, as shown in Fig. 104. In this case, of course, the girder is much lower than the sill, usually so low that it cannot be framed into the sill at all, but

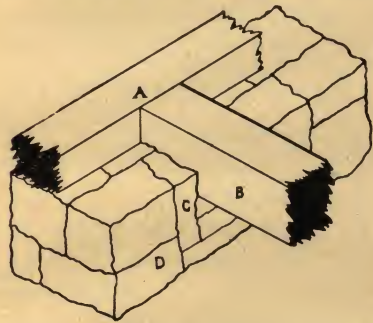


Fig. 102. Framing of Girder into Sill.

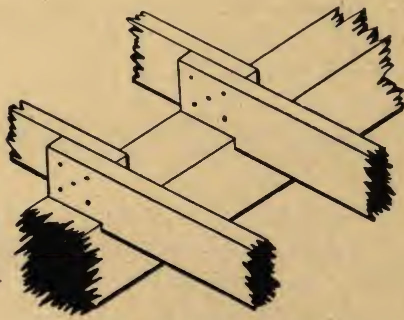


Fig. 104. Joists "Sized Down."

must be supported by the wall independently. Holes are left in the wall where the girders come, the latter being run into the holes, and their ends resting directly on the wall, independent of the sill.

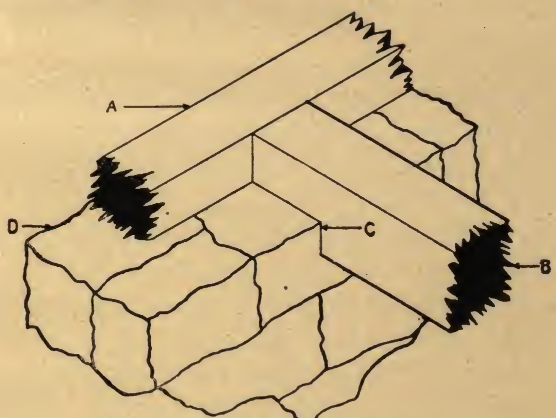


Fig. 103. Framing of Girder into Sill.

This is not very good construction, however, because the floor is not tied together as it is when the girder frames into the sill. The first method is the best and is the one in most common use.

The girders serve to support the partitions as well as to support the floors, and should therefore be designed to come under

the partitions whenever this is possible. When the distance between the outside walls is too great to be spanned by the girder, it is supported on brick piers or posts of hardwood or cast iron in the cellar. Such piers or posts should always be placed wherever girders running in different directions intersect each other. Girders are often supported also on brick partitions built in the cellar.

Joists are the light pieces which make up the body of the floor frame and to which the flooring is nailed. They are almost always made of spruce, although other woods may be used, and may be found more economical in some localities. They are usually two inches thick, but the depth is varied to suit the conditions. Joists as small as two-by-six are sometimes used in very light buildings, but these are too small for any floor. They may sometimes be used for a ceiling where there are no rooms above, and therefore no weight on the floor. A very common size for joists is two-by-eight, and these are probably large enough for any ordinary construction, but joists two-by-ten make a stiffer floor, and are used in all the best work. Occasionally joists as large as two by twelve are used, especially in large city houses, and they make a very stiff floor, but this size is unusual. If a joist deeper than twelve inches is used, the thickness should be increased to two and one-half or three inches, in order to prevent it from failing by buckling as explained in connection with the girders. The size of the joists depends in general upon the span and the spacing.

The usual spacing is sixteen or twenty inches between centers, and sixteen inches makes a better spacing than twenty inches because the joists can then be placed close against the studding in the outside walls and spiked to this studding. It is generally better to use light joists spaced sixteen inches on centers than to use heavier ones spaced twenty inches on centers. The spacing is seldom less than sixteen inches and never more than twenty inches.

Supports for Partitions. In certain parts of the floor frame it may be necessary to double the joists or place two of them very close together in order to support some very heavy concentrated load. This is the case whenever a partition runs parallel with

the floor joists, unless it has another partition under it. Such partitions may be supported in several different ways: A very heavy joist, or two joists spiked together, may be placed under the partition, as shown at A in Fig. 105. In this figure, C is the sole, B the under or rough flooring, and D, D, D the studding. This method is objectionable for two reasons: It is often found convenient to run pipes up in the partition, and if the single joist is placed directly under the partition this cannot be done except

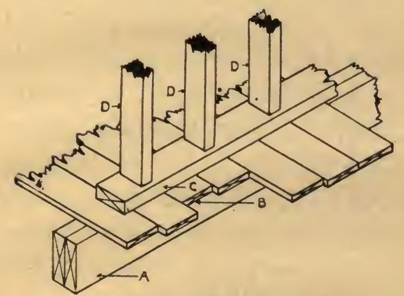


Fig. 105. Joists Supporting Partition.

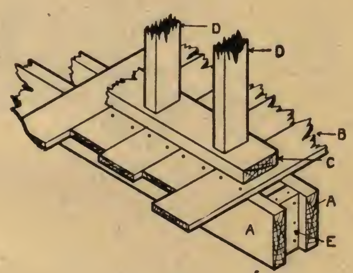


Fig. 106.

by cutting the joist and thus weakening it. Moreover, if the single joist is used, there is no solid nailing for the finished upper flooring, unless the joist is large enough to project beyond the partition studding on each side. The joist is seldom, if ever, large enough for this, and the finished flooring must therefore be nailed only to the under flooring at the end where it butts against the partition, so that a weak, insecure piece of work is the result. This may be seen by referring to the figure.

A much better way is to use two joists far enough apart to project a little on each side of the partition, as shown at A, A in Fig. 106, and thus afford a nailing for the finished flooring. These joists must be large enough to support the weight of the partition without sagging any more than do the other joists of the floor, and therefore joists three or even four inches thick should be used. They should be placed about six or seven inches apart on centers, and plank bridging should be cut in between them at intervals of from fourteen to twenty inches (as shown at E in Fig. 106), in order to stiffen them and make them act together. This plank bridging should be made of pieces of joist two inches

thick and of the same depth as the floor joists, and should be so placed that the grain will in every case be horizontal.

A partition supported as described above is bound to settle somewhat as the ten or more inches of joist beneath it shrinks in seasoning, and the settlement may cause cracks in the plastering at the corner between the partition and an outside wall. In order to prevent this settlement, partitions running parallel with the floor joists are often supported on strips which are nailed to the under side of the floor joists, as shown at A in Fig. 107. These strips cannot be allowed to project into the room below, and so they must be made as thin as possible consistent with safety. Strips of iron plate about one-half inch thick, and wide enough to support the partition studs, are therefore used for this purpose, and are fastened to the joists by means of bolts or lag screws. Partitions which run at right angles to the floor joists can also be supported in this way. If a partition runs at right angles to the joists near the center of their span, the tendency for the joists to sag under it will be very great, and they must be strengthened either by using larger joists, or by placing them closer together. If the span of the floor joists is large and the partition is a heavy one, it may be necessary to put in a girder running at right angles to the joists to carry the partition. In this case the partition studs will set directly on the girder, which may be a large timber, or in some cases, a steel I-beam.

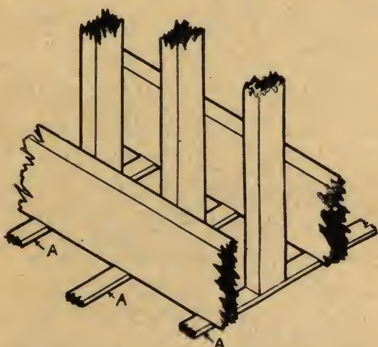


Fig. 107. Partition Supported by Strips.

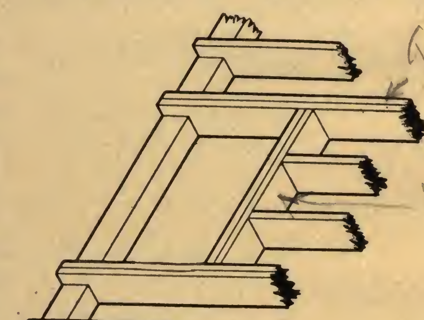

Trimmer
Header.

Fig. 108. Headers and Trimmers.

Headers and Trimmers. Another case where a girder may be necessary in a floor above the first, is where an opening is to be left in the floor for a chimney or for a stair well. The timbers on each side of such an opening are called "trimmers," and must be made heavier than the ordinary joists; while a piece called a "header" must be framed in between them to receive the ends of the joists, as shown in Fig. 108. The trimmers may be made by simply doubling up the floor joists on each side of the opening, or, if necessary, I-beams or heavy wooden girders may be used. In most cases these trimmers may be built up by spiking together two or three joists, and the header may be made in the same way.

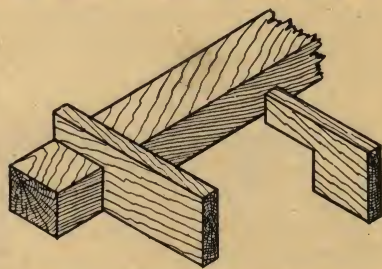


Fig. 109. Connection of Joist to Sill.

Joist Connections. Joists are also "gained" into the sill as shown in Fig. 56, in which case a mortise is cut in the sill and a corresponding tenon is cut in the end of the joist. The mortise was illustrated and described in connection with the sill, while the end of the joist is cut as shown in Fig. 56, the tenon being about four inches deep and gained into the sill about two inches. This brings the bottom of the joist flush with the bottom of the sill, and the top of the joist somewhat above the top of the sill, according to the depth of the joist. The top of a ten-inch joist would come four inches above the top of a six-inch sill, and the joist would rest partly on the masonry wall as shown in Fig. 100, thus relieving the connection of a part of the stress due to the weight of the loaded joist. A common but very bad method of framing the joist to the sill is simply to "cut it over" the sill without mortising the latter, as shown in Fig. 109. This does not make a strong connection even when the joist rests partly on the masonry wall; and if it is not so supported it is almost sure to fail by splitting, as shown in Fig. 110, under a very small loading. In fact, it would be much stronger if the joist were turned upside

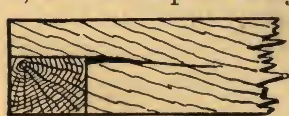


Fig. 110.

down. Frequently the joist is cut as shown in Fig. 111, where the tenon is sunk into a mortise cut in the sill, thus bringing the top of the joist flush with the top of the sill; but in this case the bottom of the joist will almost invariably drop below the bottom of the sill, and the wall must be cut away to make room for it, as shown in Fig. 102. It is also weak in the same way as is the connection shown in Fig. 110.

The framing of the joists into the girders may be accomplished in several different ways, according to the position of the girder. This placing of the girder is quite an important point. The top of the floor, on which rest the sole-pieces of the cross-partitions, must remain always true and level, that is, the outside ends of the joists must be at the same level as the inside ends. Otherwise the doors in the cross-partitions will not fit their frames, and cannot be opened or shut, and the plastering is almost sure to crack. Both ends of the joists will sink somewhat, on account of the shrinkage of the timber in seasoning, and the only way to make sure that the shrinkage at the two ends will be the same is to see that there is the same amount of *horizontal* timber at each end between the top of the floor and the solid masonry. This is because timber shrinks very much *across* the grain, but almost not at all *along* the grain. If the joist is framed properly into the sill, so that it is flush on the bottom with the sill, we have at the outer end of the joist a depth of horizontal timber equal to the depth of the joist itself, as shown in Fig. 100; and in order to have the same depth of timber at the inside, the bottom of the joist must be flush with the bottom of the girder, which usually rests on brick piers. Of course the top of the girder must not in any case come above the tops of the floor joists; therefore, in general, the

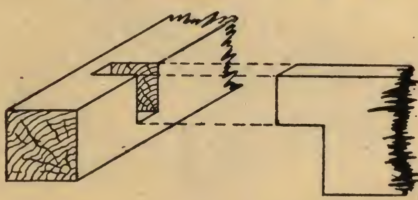


Fig. 111. Joist Mortised into Sill.

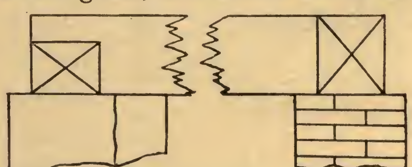


Fig. 112. Joist Framed into Girder.

girder must be equal in depth to the floor joists and flush with these joists on top and bottom, as shown in Fig. 112. This method is not always followed, however, in spite of its evident superiority; and the girder is often sunk several inches below the tops of the floor joists, as shown in Fig. 100, or even in some cases very much below, as shown in Fig. 113. Both of these methods cause an unsightly projection below the ceiling of the cellar. Where the joists are brought flush with the girder top and bottom, they may be framed into it with a tenon-and-tusk joint, the joists being cut as shown in Fig. 101, with a tenon as there shown, and a hole bored through the tenon to receive a pin to hold the joist in place.

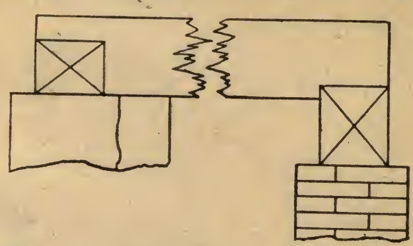
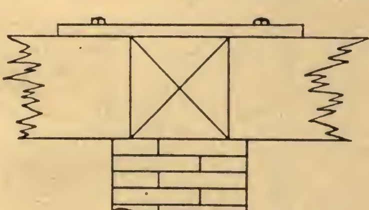


Fig. 113. Joist Sized Down on Girder.

Other methods of framing tenon-and-tusk joints are shown in Figs. 33, 34, and 35; and also a double-tenon joint in Fig. 36, which might be used in this case, although it is much inferior to the tenon-and-tusk joint. Two joists framing into a girder from opposite sides should be fastened strongly together, either by an iron strip passing over the top of the girder and secured to each joist, as shown in Fig. 114, or by means of a "dog" of round bar iron, which is bent at



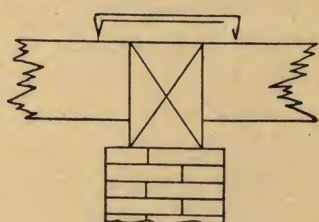


Fig. 114. Use of Straps and Dogs. Fig. 115.

the ends and sharpened so that it may be driven down into the abutting ends of the joists, as shown in Fig. 115. These bars should be used at every fifth or sixth joist, to form a series of continuous lines across the building from sill to sill.

If the girder is sunk a little below the tops of the joists, these may be gained into it in the same way as they are gained

into the sill. In this case joists should be arranged as shown in Fig. 116, so that they will not conflict with one another; and the two adjacent joists may be spiked together, thus giving additional stiffness to the floor. If the tenon-and-tusk connection is used, the joists may be arranged exactly opposite each other, provided that the girder is sufficiently wide, but it is always much better to arrange them as shown in Fig. 117, even in this case. The tenon may then be carried clear through the girder and fastened by a dowel, as shown. Very rarely a simple double-tenon joint, such as that shown in Fig. 36, might be used, but it is much inferior to either the gaining or the tenon-and-tusk joint.

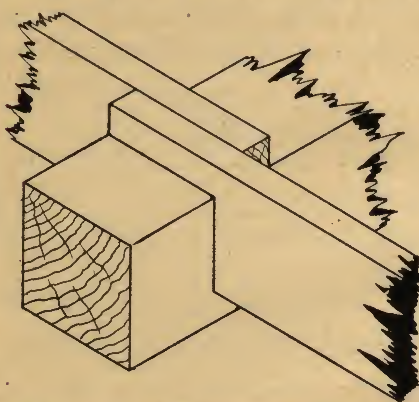


Fig. 116. Joists Framing over Girder.

If the girder is sunk very much below the tops of the joists, as in Fig. 113, these will usually rest on top of it and be fastened by spikes only, or will be "sized down" upon it about one inch, as shown. There is no mortising of the girder in either case. Joists are also thus sized down upon the girts and partition caps, and are notched over the ledger-boards as shown in Fig. 67. In cutting the joists for sizing and notching, the measurements should be taken in every case from the *top* of the joists, since they may not all be of exactly the same depth, and the tops must all be on a level after they are in place. This is really the only reason why the joists should be sized down at all, because otherwise they might simply rest upon the top of the girder, or girt, and be fastened by nailing.

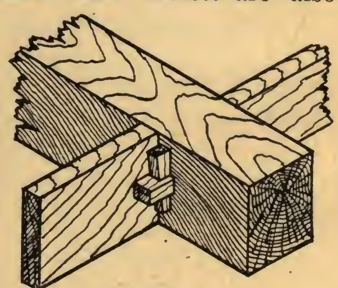


Fig. 117.

Connection to Brick Wall. When a joist or girder is supported at either end on a brick wall, there will either be a hole

left in the wall to receive it, or the wall will be corbeled out to form a seat for the beam. If the beam enters the wall the end should be cut as shown in Fig. 118, so that in case of the failure of the beam from overloading or from fire, it may fall out without injuring the wall. Every fifth or sixth joist is held in place by an

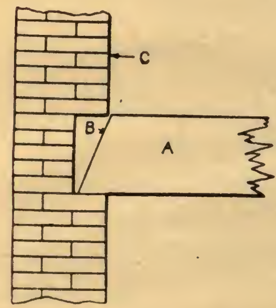


Fig. 118. Joist Supported by Brick Wall.

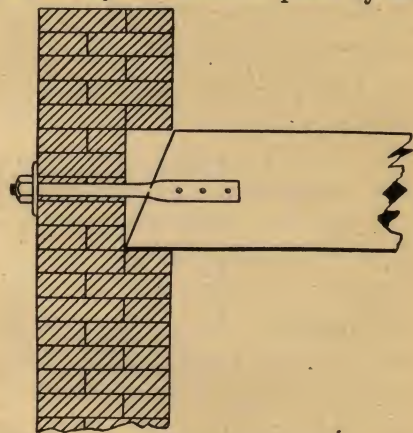


Fig. 119. Use of Anchor.

anchor (as shown in Fig. 119), of which there are several kinds on the market. Fig. 120 shows the result when a beam which is cut off square on the end, falls out of the wall.

There must always be left around the end of a beam which is in the wall a sufficient space to allow for proper ventilation to prevent dry rot, and the end should always be well painted to keep out the moisture. Patent wall-hangers and box anchors are often used to support the ends of joists in brick buildings, but only in case of heavy floors.

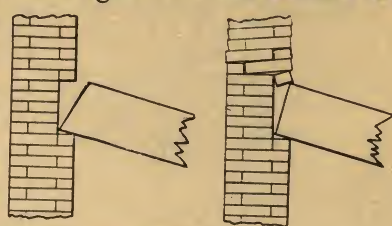


Fig. 120.

The floor framing in a brick building is the same as that in a building of wood except that there is no girt to receive the ends of the floor boards, so that a joist must be placed close against the inside of the wall all around the building to give a firm nailing for the flooring.

Crowning. In any floor, whether in a wood or a brick building, if the span of the floor joists is very considerable so that

there is any chance for deflection they must be "crowned" in order to offset the effect of such deflection. The operation called "crowning" consists in shaping the top of each joist to a slight curve, as shown in Fig. 121 B, so that it is an inch or so higher in the middle than it is at the ends. As the joist sags or deflects, the top becomes level while the convexity will show itself in the bottom as shown in Fig. 121 A. Joists need not be crowned unless the span is quite large and the loads heavy enough to cause a deflection of an inch or more at the center of the joist.

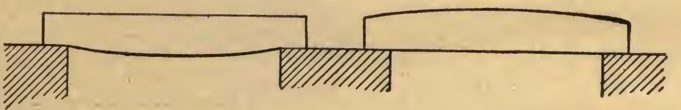


Fig. 121B. Crowning. Fig. 121A.

Bridging. Floor frames are "bridged" in much the same way as was described for the walls, and for much the same purpose, namely, to stiffen the floor frame, to prevent unequal deflection of the joists, and to enable an overloaded joist to get some assistance from the pieces on either side of it. Bridging is of two kinds, "plank bridging" and "cross bridging," of which the first has already been shown in connection with the partition supports. Plank bridging is not very effective for stiffening the floor, and cross bridging is always preferred. This bridging is somewhat like the diagonal bridging used in the walls, and consists of pieces of scantling, usually one-by-three or two-by-three in size, cut in diagonally between the floor joists. Each piece is nailed to the top of one joist and to the bottom of the next; and two pieces which cross each other are set close together between the same two joists, forming a sort of St. Andrew's cross, whence we get the name "cross bridging," or "herring-bone bridging" as it is sometimes called. The arrangement is shown in Fig. 122, and the bridging should be placed in straight lines at intervals of eight or

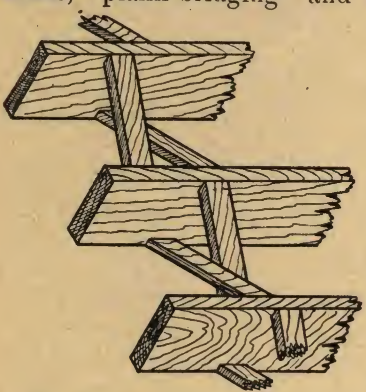


Fig. 122. Diagonal Bridging.

ten feet across the whole length of the floor. Each piece should be well nailed with two eightpenny or tenpenny nails in each end. If this is well done there will be formed a kind of continuous truss across the whole length of the floor which will prevent any overloaded joist from sagging below the others, and which will greatly stiffen the whole floor so as to prevent any vibration. The bridging, however, adds nothing to the strength of the floor.

Porch Floors. A word might appropriately be inserted at this point in regard to the floors of piazzas and porches. These may be supported either on brick piers or on wooden posts, but preferably on piers, as these are much more durable than posts. If piers are used, a sill, usually four by six in size, should be laid on the piers all around, and light girders should be inserted between the piers and the wall of the house in order to divide the floor area into two or three panels. The joists may then be framed parallel to the walls of the house, and the floor boards laid at right angles to these walls. The whole frame should be so constructed that it will pitch outward, away from the house at the rate of one inch in five or six feet, thus bringing the outside edge lower than the inside edge and giving an opportunity for the water to drain off.

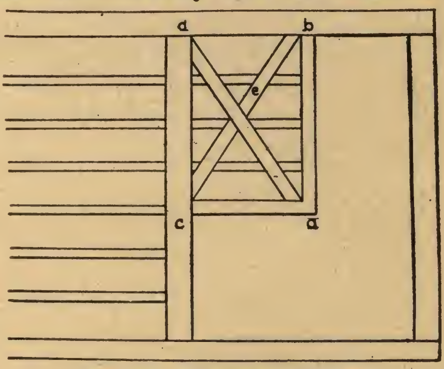


Fig. 123. Support of Corner.

Stairs. The stairs are built on frames called "stringers" or "carriages," which may be considered as a part of the floor framing. They consist of pieces of plank two or three inches thick and twelve or more inches wide, which are cut to form the steps of the stairs and which are then set up in place. There are usually three of these stringers under each flight of stairs, one at each side and a third in the center, and they are fastened at the bottom to the floor and at the top to the joists which form the stair well. This subject will be taken up more fully under "Stair Building."

Unsupported Corners. An interesting place in a floor framing plan is where we have a corner without any support beneath it, as at the corner *a* in Fig. 123. This corner must be supported from the three points *b*, *c*, and *d*, and the figure shows how this is accomplished. A piece of timber *e* is placed across from *b* to *c*, and another piece starts from *d* and rests on the piece *b c*, projecting beyond it to the corner *a*. This furnishes a sufficiently strong support for the corner.

EXAMINATION PAPER

CARPENTRY.

Read carefully: Place your name and full address at the head of the paper. Any cheap, light paper like the sample previously sent you may be used. Do not crowd your work, but arrange it neatly and legibly. *Do not copy the answers from the Instruction Paper; use your own words, so that we may be sure that you understand the subject.*

1. Give a rule for squaring a log to get the strongest possible timber out of it.

2. What is the "three-four-five rule," and how is it used?

3. Describe (and illustrate by a sketch) a splice suitable for a piece subjected to a bending stress.

4. Why is a "ledger-board" not as good as a "girt" for supporting the ends of floor joists?

5. What are partition caps and soles? What takes the place of the sole when there is a partition directly beneath the one which is being built?

6. Show by a sketch what is meant by "sizing down" a joist onto a girder or sill.

7. What is the method employed for supporting a corner which has no direct support beneath it? Make a sketch of the framing for such a corner.

8. From what two classes of trees is most building lumber obtained?

9. Give a brief description of the following varieties of timber:

a. Cypress	*d.* Spruce
b. Ash	*e.* Pine
c. Poplar	*f.* Oak

10. Name, and show by sketch, five kinds of joints used in carpentry.

11. What must take place before a "fished" splice for tension can be pulled apart?

12. What is a "raised girt?" a "dropped girt?"

13. How are furring walls around chimney breasts constructed?

14. Explain one method of framing joists into girders. Girders into sills. Illustrate with sketch.

15. How are floors "bridged?" Which is the best method? Why?

16. What is the manner of growth of the trees named in Question 9, and in what other way do trees grow?

17. What qualities are required in a wood to be used for light framing?

18. What is "ground water," and why must it be taken into account in the laying out of a building?

19. Show by sketch how the corner of a wooden building may be framed so as to give a nailing for the lathing.

20. At the point where a partition meets an outside wall, what should be the arrangement of the studding? Why?

21. Explain the method of framing around an opening in the floor frame for a chimney or staircase.

22. Give clear definitions of the following:

a. Pith	*e.* Heartwood
b. Annual Ring	*f.* Sapwood
c. Medullary Ray	*g.* Cross-grained Timber
d. Heartshake	*h.* Cupshake and Windshake

23. What is the "heel" of a steel square? the "blade?" the "tongue?"

24. What are "batter-boards?" Make a sketch of one form of batter-board.

25. How is a "key" employed in a splice for tension? What determines the distance between keys if there are more than one in a single splice?

26. What is the function of the braces in braced frames? Show by a sketch one method of bracing a frame.

27. What is meant by "crowning?" Why is it necessary?

28. Explain the effect of the shrinkage of framing timber, and explain how unequal settlement (due to such shrinkage) may be prevented.

29. What is the best method of cutting planks from a log? Why?

30. What is the "brace rule," and on what part of the square is it usually found?

31. What is dry rot, and what precautions should be taken to prevent it?

32. Does a "butt joint" make a strong connection between pieces of timber? Why?

33. What is a "beveled splice?" Illustrate by sketch.

34. Describe and show by sketch, one method of fastening the joists to the sill.

35. Why should there be trusses over window openings, and how should these trusses be constructed? Make a sketch of a truss of this kind.

36. What is the method of supporting a partition when it runs parallel to the floor joists? Illustrate with sketch.

37. Show by a sketch one form of "tenon-and-tusk" joint.

38. How should the end of a joist be cut when it enters and is supported by a brick wall?

39. What are the chief points of difference between a "braced frame" and a "balloon frame?"

40. Show by a sketch one method of "bridging" a partition. What is the best method? Why?

41. How far back from the outside face of the underpinning should the sill be placed, and how is it prevented from absorbing moisture from the masonry.

42. When is a piece likely to fail by "buckling?"

43. What is the usual size of joists in ordinary frame dwelling houses, and what is the usual spacing?

After completing the work, add and sign the following statement:
I hereby certify that the above work is entirely my own.

(Signed)